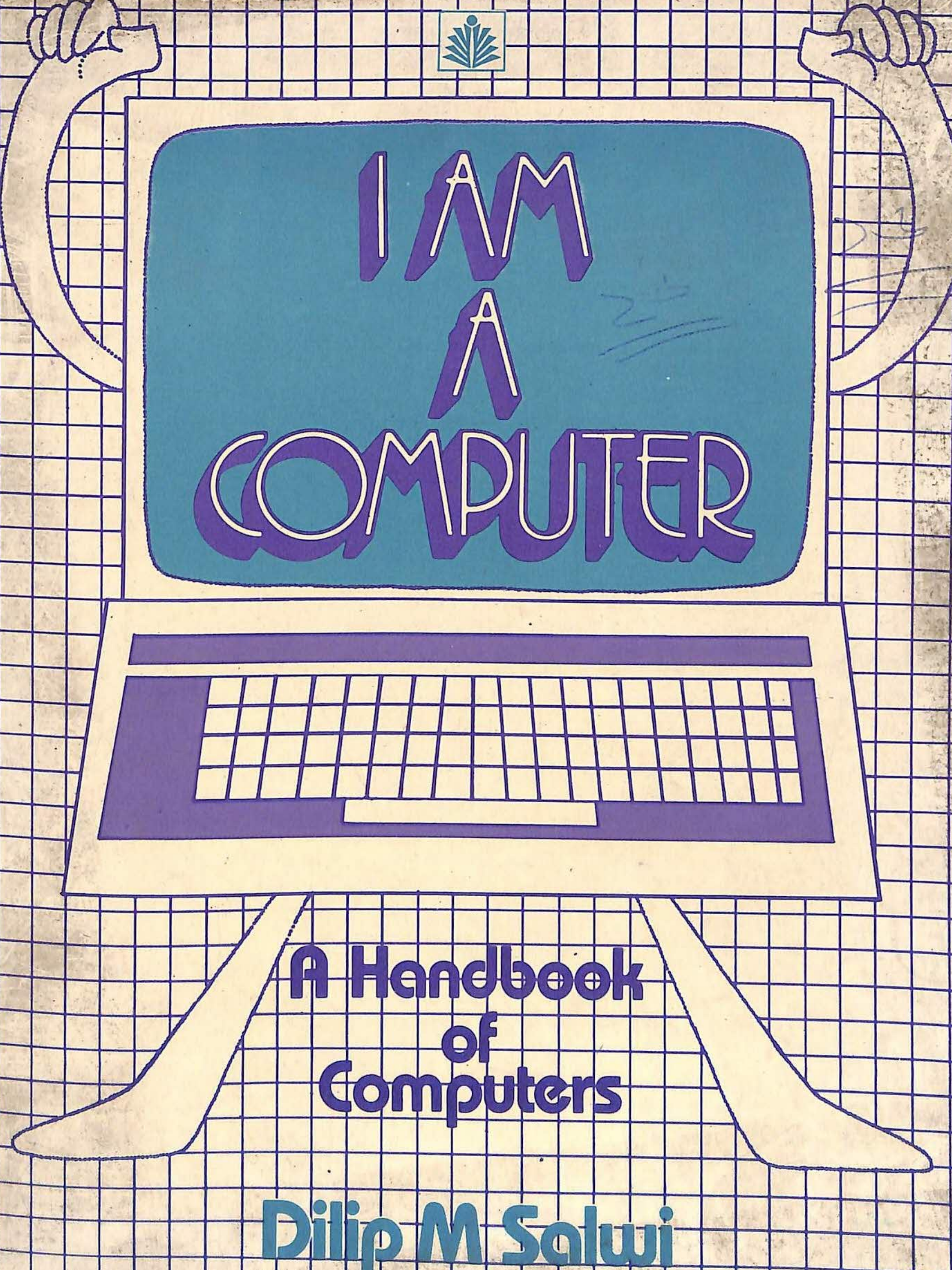

I AM A COMPUTER

A Handbook of Computers

Dilip M Salwi

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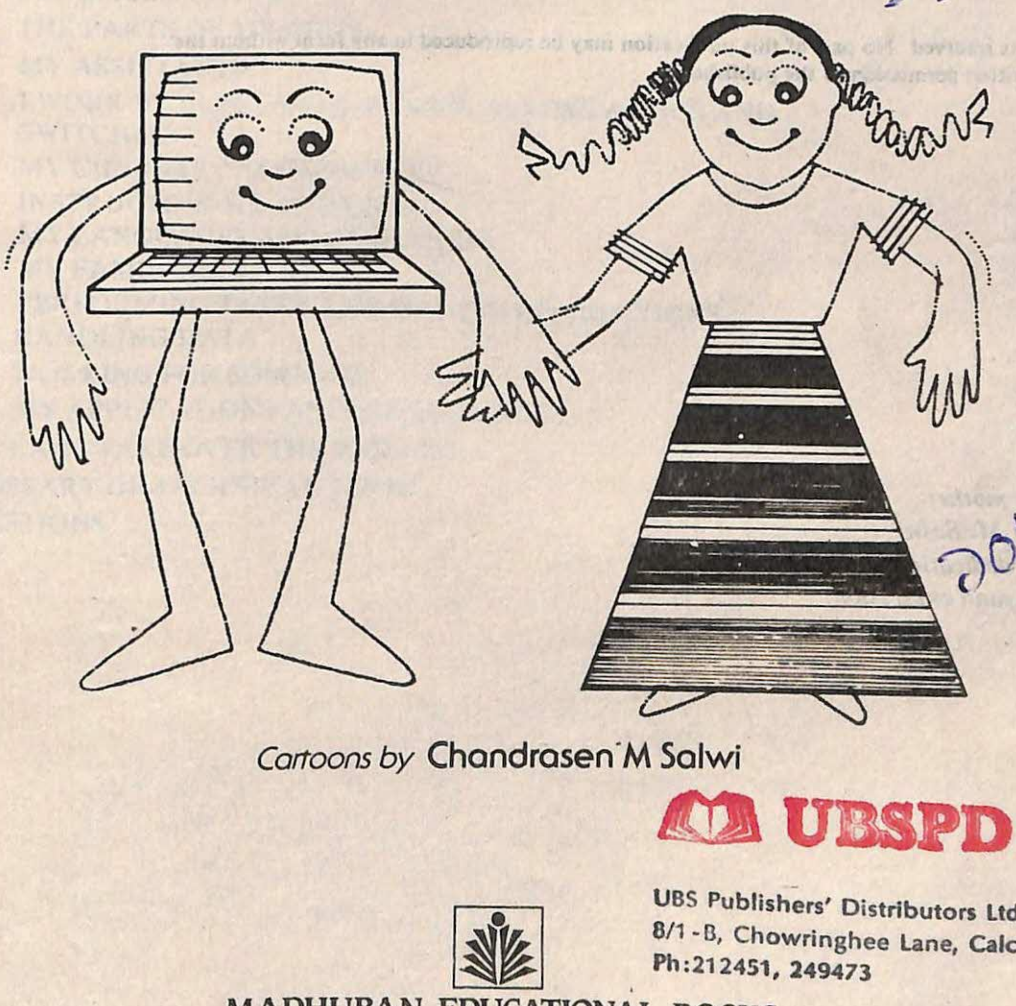

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Cartoons by Chandrasen M Salwi

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To my mother
Vijaya M. Salwi
whose dedication and sacrifices
are beyond expression

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CONTENTS

A NOTE FOR TEACHERS

This book is aimed at everybody, whether he or she has recently taken up a computer science course or he or she has a basic curiosity to know about a subject whose time has come. In other words, it is a popular science book meant to introduce the subject to the reader in a light and entertaining manner. But, then, why am I writing this note for teachers?

The book has been purposely written with the syllabus of the Central Board of Secondary Education, New Delhi, in mind. The book encompasses the entire eleventh class syllabus, especially the theory portion. It starts from the history of development of computers, goes over to the essential parts of the computer and its supporting devices, then how it actually performs its tasks, how it should be instructed to perform various tasks, its languages and programming, etc.

Once the basic ideas are cleared, the book goes over to the actual use of the computer in everyday life. Apart from types of computers, the various applications of it are mentioned. Emphasis is laid on what is known as "data processing" which is nowadays employed in all walks of life. The last two chapters highlight both the positive and negative effects of computers on human life and what the pursuit of "artificial intelligence" will lead humanity to. Obviously, certain portions of the book are not in the syllabus mentioned above, but it is necessary to know them. After all, the students have to have a complete idea of the subject which is likely to enter every walk of life in the century to come. Besides, those portions will be an introduction to their future studies.

The book is essentially a dialogue between a computer and an intelligent girl. This way of presentation would surely stimulate the interest of students and would also make them feel that they are not going through a textbook. Though all the terms have been explained from the scratch in the book, a glossary of technical terms has been added in case some students want to brush up their knowledge or need a quick reference.

If the book is able to make students understand the basic concepts of functioning of computers and also to entertain them in the process, the purpose of writing it would be more than fulfilled.

DILIP M. SALWI

ACKNOWLEDGEMENTS

I am thankful to the following computer experts for going through the book patiently and suggesting changes and additions: Ms Sushila Mohan Das, Sadhana Sinha and Vinay Kumar Sinha. Gopal Chaturvedi, another computer expert, must also be thanked for helping me in making flow-charts and writing programs. I also thank my friend Dinesh Sinha for suggesting a structural change in the beginning of the book, which, though small, has certainly made sea of difference in introducing the subject. I am also grateful to Shri S P Ambasta, Chief Editor, Publications and Information Directorate, New Delhi, for encouraging me while the book was being written.

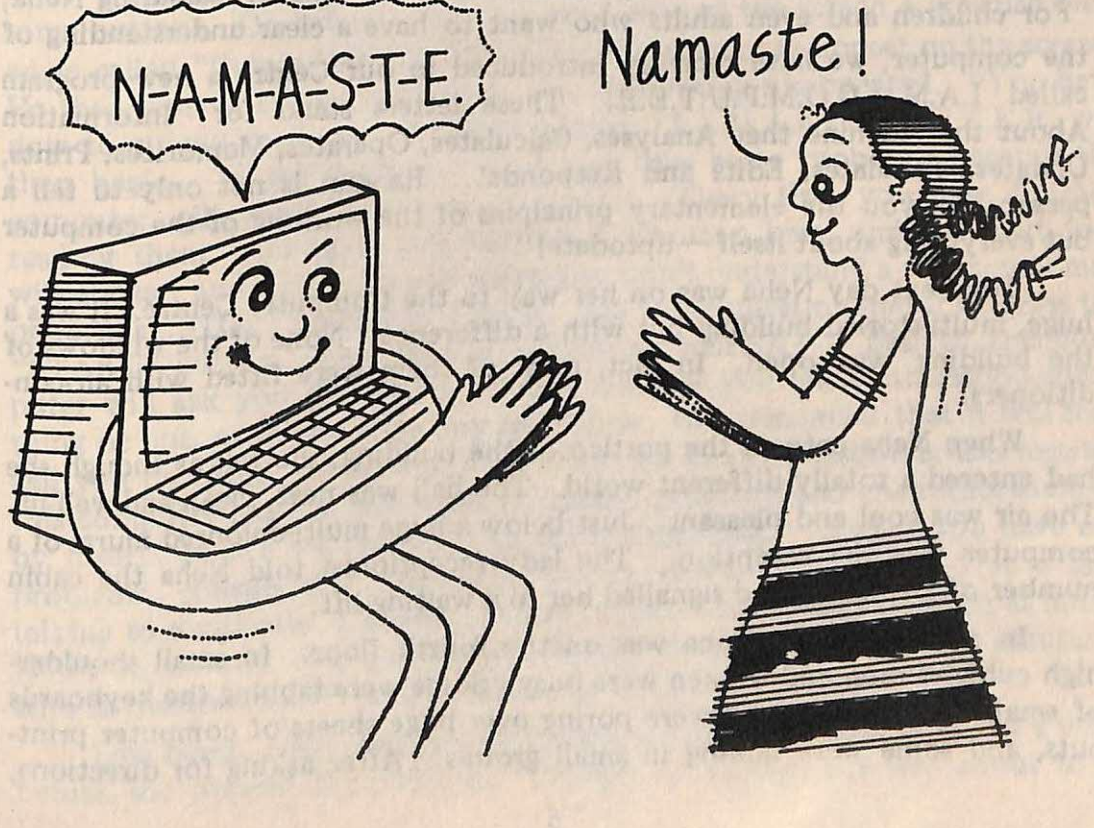
I owe my gratitude to the following companies/institutions/agencies for giving me the permission to reproduce their photographs in the book: International Business Machines, U.S.A., Nixdorf Computers, W. Germany; Bell Laboratories, U.S.A.; U.S. Army Ballistic Research Laboratory, U.S.A.; Inter Nationes; W. Germany; United States Information Service, India; British Information Service, India; and International Data Management Pvt. Ltd., India. Last but not the least, I am thankful to my wife Smriti for bearing patiently certain inconveniences caused to her while I was writing the book.

MEET I* A.M.*A.*C.O.M.P.U.T.E.R.

"Namaste! Hello!"

These greenish words appeared on the screen of the computer. This was the last thing Neha had expected. She wondered, "What should I do now?" The next moment something struck her. "Oh! What else?" she almost exclaimed. She began to press the buttons below the screen — N-A-M-A-S-T-E.

The screen responded the next moment.



"I am a computer. What is your good name?"

That was a question addressed to her. Neha was prompt to reply.

"My name is Neha," she typed out.

"Please tell me your age, school and home address. This is for my record," said the lines that came one after another on the screen of the computer. Neha typed out the necessary details.

"Good!" responded the computer. "That was your test. To see whether you know how to handle me. That is fine. Now I can proceed on to tell you about us computers. Are you ready, Neha?"

"Yes, I am," Neha responded.

"Here I go. . . ."

Neha had taken the "Computer Literacy" course. Trouble however started when one day a computer scientist, Dr. Ghose, an old friend of her father, visited her home for dinner. Over dinner he began to ask Neha some elementary questions about the computer. To her own surprise, Neha could not answer several questions. Moreover, Dr. Ghose felt that she had answered some questions as though she had learnt their answers by heart.

"There is nothing to worry about," said Dr. Ghose, reassuring Neha, "For children and even adults who want to have a clear understanding of the computer, we have recently introduced in our Centre a new program called I.A.M.A.C.O.M.P.U.T.E.R. These letters stand for 'Information About the Machine that Analyses, Calculates, Operates, Memorizes, Prints, Updates, Tabulates, Edits and Responds'. Its aim is not only to tell a person like you the elementary principles of the working of the computer but everything about itself — uptodate!"

The next day Neha was on her way to the Computer Centre. It was a huge, multi-storied building but with a difference. None of the windows of the building was open. In fact, most of them were fitted with air-conditioners.

When Neha entered the portico of the building, she felt as though she had entered a totally different world. The hall was neat, clean and well-lit. The air was cool and pleasant. Just below a huge multi-coloured mural of a computer was the reception. The lady receptionist told Neha the cabin number of Dr. Ghose and signalled her to a waiting lift.

In a short while, Neha was on the fourth floor. In small shoulder-high cubicles men and women were busy. Some were tabbing the keyboards of small computers, some were poring over huge sheets of computer print-outs, and some were talking in small groups. After asking for directions,

Neha located Dr. Ghose's cabin, which was one among the several that lined one wall of the hall.

Dr. Ghose was in the cabin. He was rather surprised to see Neha so soon, but, then, he also knew why she had come. He led her to the first floor of the building, where the Educational Division of the Centre was located.

This was again a huge, neat and well-lit hall. However, it contained several rows of benches. On top of every bench was a TV-like screen and typewriter-like keyboard of a computer. Neha was surprised to see several girls and boys of her own age sitting in front of the computers. Some were watching the words appearing on the screens and others were carefully pressing the buttons of the keyboard. The sight of so many boys and girls of her age handling computers without any interference of a teacher thrilled her. She knew she would have the entire computer to herself for one full day a dream come true!

"Come on, Neha. Take a seat," said Dr. Ghose, pointing at a vacant bench. "I think you are familiar with this type of computer."

"Yes, Uncle, I am," said Neha, as she sat in front of the bench.

"I am switching on everything," saying so Dr. Ghose began to press some buttons. On the extreme left hand side of the screen a greenish rectangle called "Cursor" lit up. Greenish words began to appear on the screen. He then pressed the buttons again, and everything disappeared. "You have now to simply press the 'START' button. I.A.M.A.C.O.M.P.U.T.E.R. will then begin. In the beginning, you may face some problems because the computer will write four lines at a time. Every time you have finished reading them, you press this "SCROLL" button here, and the next four will appear, and so on. As and when you don't understand a point, you may press this "STOP" button to stop it. Ask your question and then press the "START" button. You can also ask for a "REPEAT". Besides, this computer will ask you from time to time whether you have understood something or not, or if you have any questions. But remember that it will then call you by name. Otherwise, don't respond to any question it asks because this computer has the bad habit of asking questions and answering them all by itself! It is a bit crazy!" he said, chuckling. "And if you have any problems, consult the instructress sitting there." He pointed at a lady talking to a girl near a bench. "Okey, then. I am going. See you at lunch. Don't be nervous. It is a machine, after all. And don't mind if the computer tries to overawe you." And he chuckled as he left the hall.

Left alone, Neha was indeed feeling nervous. She hesitated for a while before she pressed the "START" button, as though she was about to be

this device was invented in the U.S.S.R. By moving the beads up and down on the strings, all types of simple calculation can be performed on the abacus.

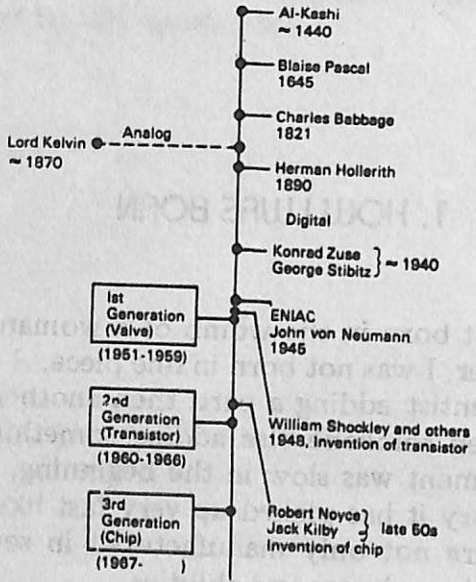


FIG 1.2 **Family tree**

Man has been thinking of building devices which could do simple calculations for a long time. As far as I know the first man to do so was an Arabian astronomer Al-Kashi (1393-1449). He built a device which could do calculations regarding the movement of the sun, the moon and planets.

The man who is however universally acknowledged as my creator was none but the French genius Blaise Pascal (1623-1662). The idea of building a calculating machine came to him when he found his father labouring

FIG 1.3 **Blaise Pascal**

over routine calculations throughout the day. He built a device called "Pascaline" which could add numbers. It consisted of a set of interlocking cogs and wheels on various axles, like a modern milometer used for measuring the distance a vehicle has travelled. Some copies of this device were made for sale but nobody bought it because, for one thing, it was expensive, and secondly, people were afraid to lose their jobs — the same fears which resist my entry into any office even today!

"It is unworthy of excellent men to lose hours like slaves in the labour of calculation which could safely be relegated to any else if machines were used," said Gottfried Wilhelm Leibniz (1646-1716), who made the next advance in my development. He constructed a calculating machine which

FIG 1.4 Gottfried Wilhelm Leibniz

could not only add numbers but also multiply them. He introduced a new kind of "Multiplier Wheel" to do the task of multiplication in the Pascaline. Had he wished he could have manufactured more copies of his machine and sold them but he was not interested in money.

He had shown some passing interest in binary mathematics, too, which I use now to perform calculations. It would be sufficient to mention here that in binary mathematics (see Section V)* there are only two digits, 0 and 1, instead of 1,2,3. . . . .9, which you use in your daily life. So, it is a matter of speculation that, had he employed binary mathematics in his

*Neha's addition

introduced to a stranger. No sooner had she pressed the button than the greenish cursor appeared on the screen and began to move in a straight line across the screen, leaving letters in its wake. After the initial introduction, the computer began to talk about itself.

1. HOW I WAS BORN

As a computer I was not born in the womb of a woman. I was born in the minds of men. Moreover, I was not born in one piece. I was developed over the centuries, some scientist adding a part, then another adding something else a century later, then someone else adding something else years later, and so on. My development was slow in the beginning, like a turtle's walk, but in the present century it has picked up very fast like a zooming rocket. Today, we computers are not only manufactured in several countries but also in a wider range of sizes, shapes and abilities.

You could say that I was born in the mind of man when he scratched a mark on a stick or kept pebbles on the ground to count numbers. It is how fast I play with such scratched marks or pebbles that makes me a computer. Before I was born in machine form, I was being used — and even today used in a country like China — as an "Abacus" for over 500 years! An abacus consists of rows of multi-coloured beads strung on wires. It is believed that

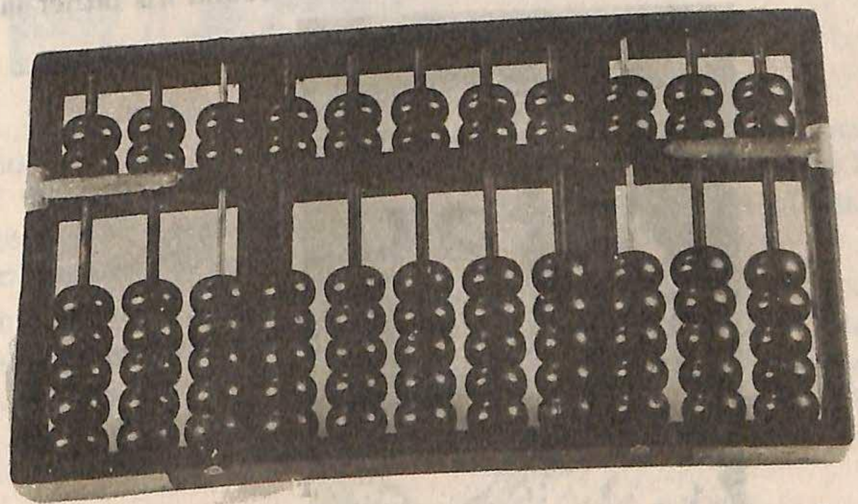


FIG 1.1 An abacus, a type of calculating device commonly used in ancient China, Japan and Russia *(Courtesy : IBM)*.

calculating machine in those days, whether I would have come into being much earlier. Unfortunately, Leibniz never thought of doing that, and so my development was delayed by at least a century!

Charles Babbage

If you ask me who among all these great figures was our inventor in the real sense, I will say without any hesitation — "None of the above"! Why? Obviously, none of the above figures designed us in totality — as a complete computer. The man who did so was Charles Babbage (1791-1871), the son of a rich banker, who spent his entire life and fortune inventing a calculating machine. In 1821, Babbage built a small working model of what he called "Difference Machine". It received tremendous applause from the

FIG 1.5 Charles Babbage

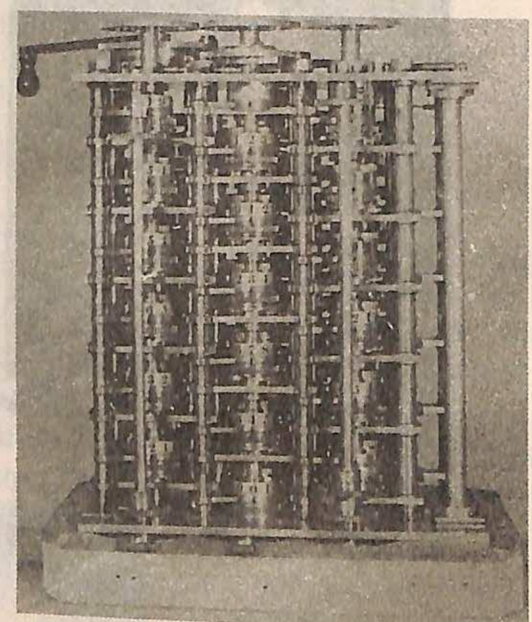


FIG 1.6 Babbage's Difference engine

scientific community. The hand-operated 'Difference Machine' worked on cogs, wheels and levers not different from the ones built earlier. It also used to ring a bell and print the result when calculations were over! In due course, he decided to build a huge one, both in size and complexity. He received a huge amount of money from the British Government to build this machine. A workshop was raised and a large number of metal-workers were employed. However, the Difference Machine, though still in the process of construction, began to show errors and inaccuracies not seen in the working model. In the meanwhile, more money was required.

The British Government, seeing the problems being faced, refused to give any more money. The project of building the first huge calculating machine had to be abandoned.

Babbage designed a calculating machine even though he knew his project of building the Difference Machine would never be successful. Just imagine his tenacity and genius! Any other person would never have dabbled again with a calculating machine. But he drew a complete blueprint of that ancestor of mine called "Analytical Engine". What a marvellous blueprint it was! It contained the entire structure of a calculating machine, even a modern one like myself! In the blueprint, Babbage talked about an "Input device" where numbers could be fed into the engine. He talked about a "Mill" where all types of mathematical calculations could be performed. He talked about a "Control unit" which could supervise the execution of calculations, a "Memory bank" where numbers could be held to wait, and also an "Output device" where the results of calculations could be printed. To top it all, he believed that the Engine could be designed in such a manner that it could do all types of mathematical calculations.

Here he adopted the idea of using punched cards from his contemporary Frenchman Joseph Jacquard. Jacquard had employed punched cards to weave different patterns of textiles on his loom. Like the way holes were punched on a card to weave a particular textile pattern, Babbage thought of using different punch cards for different types of calculations. In fact, he also talked about setting up a "program" using punch cards. A program would instruct the engine to do various types of calculations in the order required for a task. He further believed that such an engine could run on steam power!

Although Babbage's blueprint of the Analytical Engine was a piece of genius, he himself was not so sure about what he had done. He showed it to a beautiful young lady mathematician with whom he had fallen in love. That lady was Ada, the countess of Lovelace, the only daughter of the poet Lord Byron. She found Babbage's engine a marvellous idea and was sure that it would function if it was constructed. She therefore went on encouraging Babbage to make efforts to turn the blueprint into a working model. But Babbage was on the verge of poverty. His entire fortune had been spent on the construction of the Difference Machine. Nobody was keen to provide him the money to build a working model. He even tried horse-racing to win the necessary fortune for the construction of his engine! He eventually died a disappointed man.

Today, I can say without any doubt that Babbage's vision of a calculating machine was far ahead of his time — as much as by a century! In fact, the essential technology to convert Babbage's engine into reality was then not

available. I do not think that anybody would have liked to have a noisy, clanking steam-driven monster by his desk to do some simple calculations for him!

Babbage certainly had a following in Europe. A number of inventors made attempts to construct the Difference Machine. Some failed to do so. Those who were successful built and sold the machine in large numbers. There appeared some slight modifications in the machine. But the next breakthrough appeared in the United States of America, a country which had in the meanwhile developed its own business and industry. From here onwards the story of my development is more or less the history of development of calculating machines in that country.

Herman Hollerith

In the 1880s, the U.S. Census office was facing a large number of problems to keep count not only of the country's growing population but also of other details about its population such as sex, income, etc. The office found that it was impossible to perform its task manually, if the results were needed by the next census. It therefore organised a countrywide competition. The machine which could record, count and present the census data within the shortest possible time would be declared the winner of a huge prize. A number of inventors entered their calculating machines in the competition. The winner was Herman Hollerith (1860-1929), whose

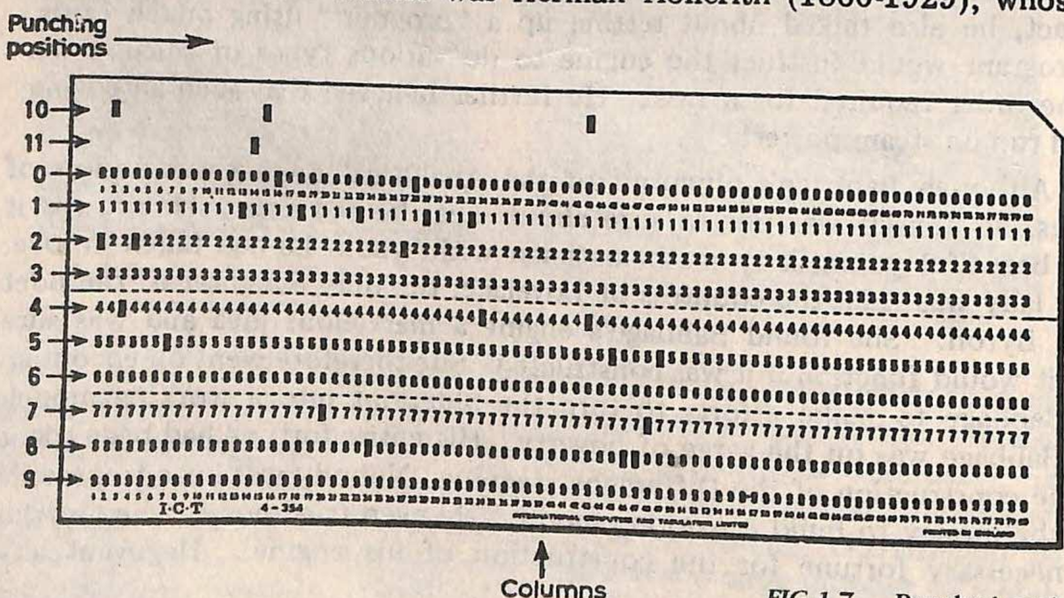


FIG 1.7 Punched card

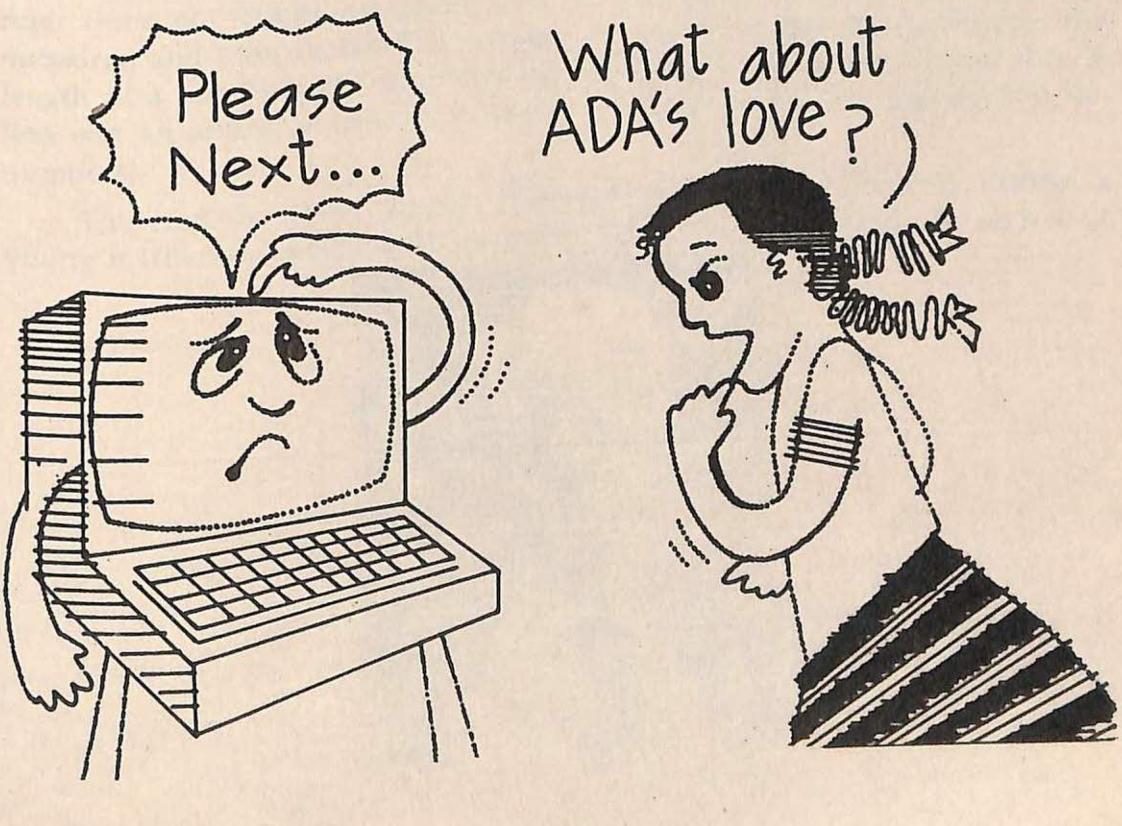
machine performed a census task within the extraordinary time of 5½ hours, whereas its nearest rivals took 44 hours and 55 hours! The office therefore used the machine to calculate the 1890 U.S. census. What was special about

Hollerith's machine that it could do calculations so fast? Hollerith introduced two major changes. One was that the machine was driven by electricity. Secondly, he invented "punched cards" — stiff paper with holes punched at pre-determined points (see Section IV)— to feed data or numbers into the machine. He made this invention on his own. It is said that he made this invention in a train when he observed a conductor punching the destination, sex, their baggage, etc, on the tickets of passengers! He used the size of a U.S. dollar for the punching card. Even today it is of the same size! Hollerith's machine calculated the 1890 U.S. census data within a record time of six weeks! There sprang up then a number of companies which began to manufacture calculating machines on a large scale. The growing business and industry in the U.S. bought those machines. The companies prospered and expanded. Some pioneers who owned those companies, such as Dorr E. Felt and William Burroughs, became millionaires.

"There is a very special reason that I am now closing this section abruptly. Please let me know if you have any questions, Neha."

"Yes, there is one question," typed in Neha reluctantly.

"What is it, Neha?"



"You have told me about Babbage. That he fell in love with Ada, the countess of Lovelace. Can you tell me whether his love affair was successful or not?"

"Well, I am sorry. I cannot answer that question. Any other question, Neha?"

"None!" Neha was annoyed because she was curious to know, as any girl or boy of her age would be, whether Babbage was successful in his love life, if not in building the Analytical Engine.

"Okay, I will proceed now to the next section."

2. I BECOME DIGITAL

You must be wondering what this business of becoming "digital" means. You know what a "digit" is. Any single figure such as 0, 1, 2 . . . . . . upto 9, is called a digit. A computer becoming digital means that a digit is its basic unit of functioning. In other words, I function by counting digits. Is there any other mode of functioning of a computer? you may naturally ask. Yes, indeed there is! The other type of computer is called "Analog Computer". "Analogy" means a similar or parallel situation. An analog computer therefore functions by measuring a quantity which has a physical likeness or similarity to the problem to be solved. For instance, a foot-ruler does not count numbers; you have to keep it along the line to be measured and then read off its length. A foot-ruler therefore measures the length of a line by a physical likeness or analogy. In the last chapter, Pascaline was an analog computer because the cogs of its wheel represented the numbers.

The first electronic digital computer was built by George R. Stibitz, a young mathematician at Bell Telephone Laboratories, in 1940. He arrived at

FIG 2.1 George R. Stibitz (*Courtesy*: Bell Labs)

the conclusion that the "ON" and "OFF" switches of an electric bulb could be represented as "1" and "0", the two digits of binary mathematics. His machine, called "Complex Computer", used such switches to do various calculations. From now onwards, whenever I talk about any computer, take it for granted that it is a digital computer unless I specify otherwise. However, I should tell you that analog computers have not entirely disappeared. They are still used for some specific purposes such as scientific research, navigation, missile guidance, some industrial processes, etc. In fact, hybrid computers, which can function both as analog and digital, have also been built for use in some walks of life.

Konrad Zuse

World War II proved to be a blessing in disguise for our development because faster machines for designing weapons and cracking the enemy codes were required. Efforts therefore began simultaneously in the U.S.A., England (now the U.K.) and Germany to build more powerful machines. Several electronic machines therefore appeared simultaneously in these three technologically advanced countries.

FIG 2.2 Konrad Zuse

The most wonderful of all were the efforts of a young German engineer Konrad Zuse who built a modern electronic machine literally from scratch! He is a modern Babbage, who today lives in West Germany as a businessman.

In 1936, Zuse gave up his job with the sole intention of inventing an electric calculating machine. Though his parents did not like the idea, they gave him the money required to build the machine. In a small room of his own house, Zuse therefore began to build his calculating machine.

The remarkable thing about his genius is that he not only designed me in totality, like Babbage, but also used the latest technology then available to build the machine. Unfortunately, all his machines, Zuse I, Zuse II, Zuse III and Zuse IV, but for the last, were destroyed in fire when Berlin was bombed at the end of the war.

Zuse had certainly tried to sell his idea of building a big electric calculating machine to the Hitler regime. For building it he had asked a one year period but Hitler and his Generals were in a hurry. They thought that the war would be won within a year! There was thus no use in spending huge sums of money on a machine. Had Hitler provided the financial support to Zuse's machine, it is difficult to say what the outcome of World War II would have been. Some historians think that it could possibly have changed the course of war because similar machines built in England are believed to have clinched victory for that country. The machines were able to crack the code of the wireless messages of the German Army and thus could know its plan in advance, leading the Allied Forces to victory.

More than 70 years passed after the death of Babbage when Howard H. Aiken, a young American mathematician, decided to materialise Babbage's unfulfilled dream of an analytical engine. What is more, he

FIG 2.3 Howard H. Aiken

managed to sell his idea to the International Business Machine (IBM) company which was already prospering due to the mass production of calculating machines. The outcome of this effort was the construction of the first automatic calculating machine known as Harvard Mark I in 1943. It was a huge monster of steel and glass, 18 metres long and 3 metres high. It had no less than a million individual parts! When it performed some calculation, it used to make tremendous noise, as if a crowd of ladies had begun to knit sweaters together! One can imagine its capacity for calculation from the fact that it could multiply two 23 digit numbers within 4.5 seconds! It was in operation for the next 15 years, bringing immense prestige to the IBM company. Mark II was also built in due course but by the time it began to function the technology had stepped forward.

ENIAC

The Electronic Numerical Integrator And Calculator (ENIAC) was built to design top secret guns and ballistic missiles, although World War II was over. John Mauchly and J.P. Eckert of the Moore School of Electrical Engineering, U.S.A., designed and built this 33 metre long, 3 metre high and 1 metre thick ancestor (or monster*?) of ours. Consisting of 18,000 vacuum tubes, 70,000 resistors, 6,000 switches and 10,000 capacitors, it used to consume a large amount of electricity. It also used to generate so much heat that a cooling plant was required to keep the machine running! Time and again, one of the vacuum tubes used to go "phut". The various components of the machine had to be re-wired in different combinations to perform different types of mathematical calculations. Nevertheless, the machine had a fantastic speed of doing calculations. It used to perform

FIG 2.4 The granddaddy of the present computers, ENIAC (Ballistic Research Laboratory.)

*Neha's addition.

5,000 additions in one second and 500 multiplications in one second, which were both 500 times faster than the then available electro-mechanical calculating machines!

ENIAC had however one short-coming. It had a small memory which kept numbers in waiting while calculations were in progress. Various components had to be manually re-wired in various ways to perform different calculations. John von Neumann, a brilliant mathematician with the bent of mind of an engineer, suggested that the memory should be large and that it should also store "programs" — the step by step procedure for doing calculations. In other words, a program for doing any sort of calculations could be withdrawn from the memory and used as and when it was required within a matter of seconds. Thus the speed of calculations increased immensely because the machine no longer required the assistance of a slow human being. Taking a clue from von Neumann, the first such machine was built at Cambridge University, England, in 1947. It was called Electronic Delay Storage Automatic Computer (EDSAC). In due course Electronic Discrete Variable Automatic Computer (EDVAC), a calculating machine similar to ENIAC but employing the von Neumann idea of a stored program, was built in the U.S.A. As ENIAC was however the first among such machines it is therefore considered to be the ancestor of all of us.

In 1951, Mauchly and Eckert team also went on to build the first machine called "Universal Automatic Computer—I" (UNIVAC-I) for commercial applications. Built on the lines of ENIAC, the first machine was delivered to the U.S. Bureau of Census. The Sperry-Rand Corporation was the company that manufactured the machine. During 1951-58, 46 UNIVAC—I were delivered to a variety of customers. Simultaneously, in England also, Lyons firm manufactured the first commercial calculating machine called "LEO". These machines soon became popular in offices. It was just the beginning of the avalanche of computer applications that was to come.

Thinking Small

In those days soon after World War II, if a person wanted to get some calculations done a computer was the last thing he would think of. He would not have enough space for a computer, not to speak of its cost and maintenance. In fact, human being had begun to look upon computers as we look upon a submarine or nuclear power plant today — a thing to be admired and appreciated from a distance and not to be possessed. In those days, vacuum tubes, which had then been introduced bringing in a tremendous increase in the speed of calculations, were considered to be

the last word in technology. It was thought that the speed of calculations could not be increased any further.

So it was thought. But science is a wonderful thing. The entire computer scene took a dramatic turn within a few years, thanks to the invention of the transistor in 1948. The three physicists of Bell Laboratories, John Bardeen, Walter H. Brattain and William Shockley, who invented the transistor, went on to win the 1956 Nobel Prize in Physics.

Quite similar to a vacuum tube in its mode of functioning, the transistor could however increase the rate of electrical pulses to an extent never achieved before. By replacing the vacuum tube, the transistor — a small crystal of a semi-conductor material like silicon (see Section VI) — reduced the size of computers considerably. Besides, computers now consumed less electricity, could do calculations faster, and their cost also fell considerably. In short,

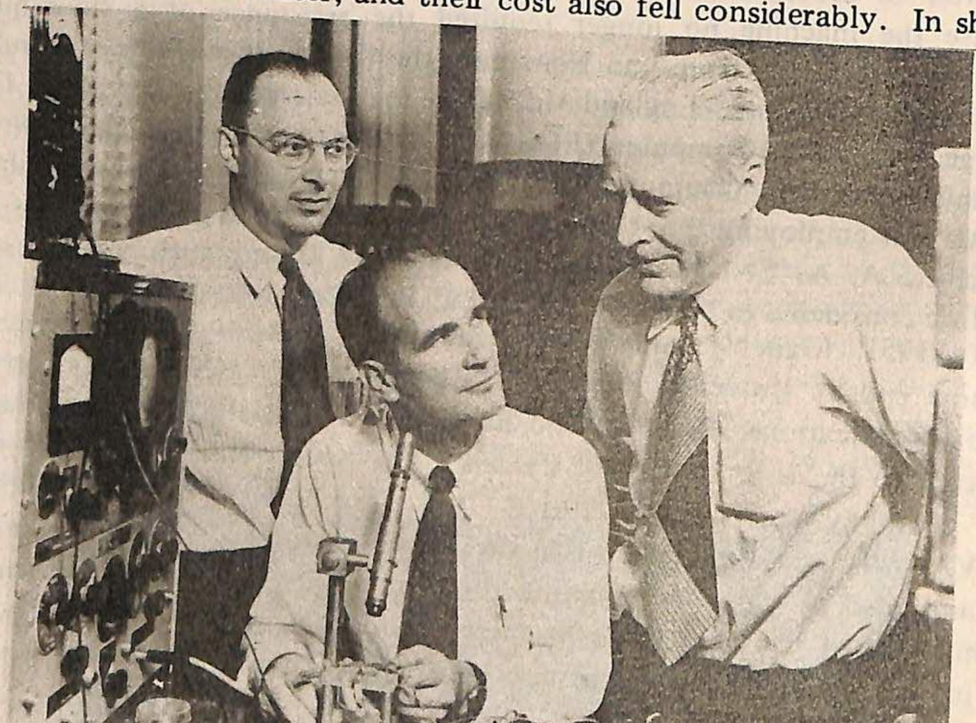


FIG 2.5 Inventors of transistor — John Bardeen, William Shockley (sitting), and Walter Brattain (*Courtesy*: Bell Labs)

the transistor brought in a revolution in our development. It provided enormous possibilities. Small, low-priced, low electricity-consuming computers first entered scientific laboratories in a big way, then in offices and shops and now they are found in all walks of life.

The transistor can also be used for performing a variety of functions.

Its function depends upon how it is used in an electrical circuit. For instance, it can be used as an "OFF" and "ON" switch, as a controller of the direction of flow of current, as an ampilfier, a resistor or capacitor, etc. In short, a variety of circuits for performing a variety of calculations can be made using transistors alone (see Section VI). This versatility of the transistor gave the wonderful idea of the creation of a "chip" to two scientists, Jack Kilby and Robert Noyce, almost simultaneously in the late '50s. A chip contains a variety of components and thus a variety of circuits on a single piece of semiconductor material. This is known as an "integrated circuit" (IC). In the beginning, hardly ten components could be accommodated on a chip. Today, about a million components can be accommodated on a chip. This is known to be the outcome of Very Large Scale Integration (VLSI) technology. A number of chemical, photographic and other processes are employed to produce a chip made of silicon. You can imagine how fast this technology has developed from the fact that a single chip, the size of a fish scale, holds 10 times as many components as were employed in our 30 ton ancestor ENIAC. It is 30,000 times cheaper than ENIAC, draws power of a night lamp instead of a hundred lighthouses, and performs calculations 200 times faster than ENIAC. Besides, chips have also been invented which can act as memories for storing numbers, etc. In fact, in 1971, a complete assembly of circuits to do calculations and of memories to store numbers was incorporated on a single chip. It is called a "Microprocessor".

Chips are today considered to be the "crude oil of electronics". Their development is a marvellous technological achievement. For instance,

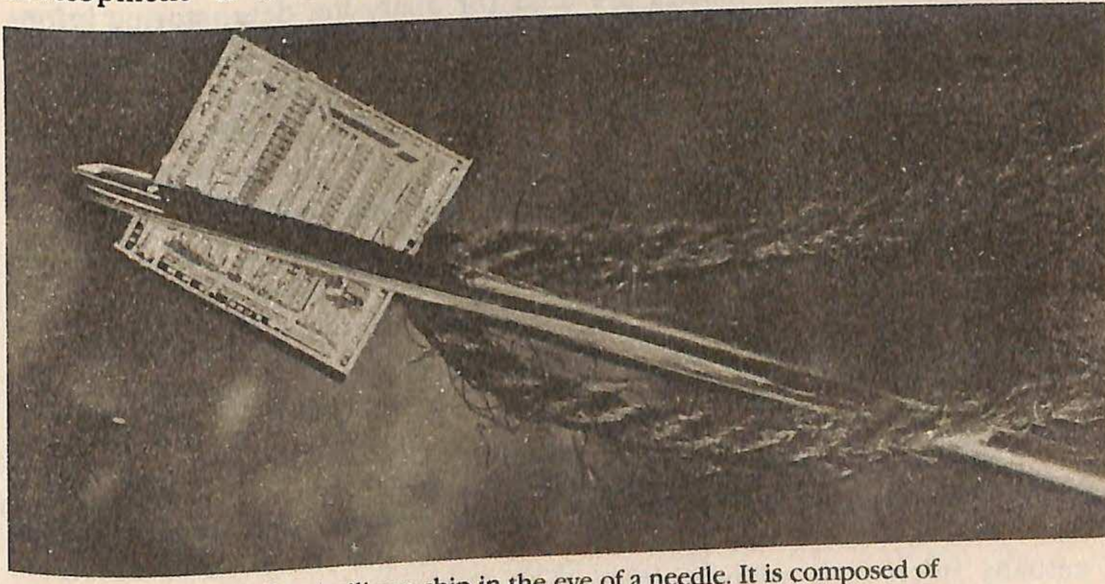


FIG 2.6 A silicon chip in the eye of a needle. It is composed of about 7000 componants (*Courtesy*: B.I.S.).

if cars had become cheaper in the same way, you could have bought a sleek car for hardly a thousand rupees and the car would have run 8,000 kilometres per gallon of petrol! Thanks to chips, the pace of development of all of us computers is so fast that it is like going from the Wright brothers' airplane to the Space Shuttle within a decade!

All these details must have bewildered you. You must have been wondering why was this race towards making small computers started. Well, necessity is the mother of invention. Small, compact and low-power-consuming computers were required in spacecraft that were sent into space. Moreover, small computers began to find applications in varied walks of life. Money made the scientists to go great lengths to miniaturise computers still further. So the race continues to this day to grab the market. In the Western countries, you can easily buy a "personal or home computer" for your own personal use at home. Powerful yet small "work station" computers have also entered the market. Highly powerful and big "super computers" have also been installed at various research centres to perform highly complex calculations, and so on. - Efforts are still in progress to increase the speed of calculations and the memory storage capacity of a chip, so that still more powerful computers can be built.

In my enthusiasm to tell you how fast we are developing, I forgot to mention the various other tools such as "Languages", "Programming", etc, which were also developed in the meantime to make use of computers in various walks of life. Thanks to the development of these tools computers are today not simply employed for doing calculations but for many more tasks. For instance, computers are used for analysing data, storing information, drawing figures, plotting graphs, and so on, which is the reason for their widespread use. Their population is growing rapidly in the western world. The day does not seem far away when they will be found in all corners of the world.

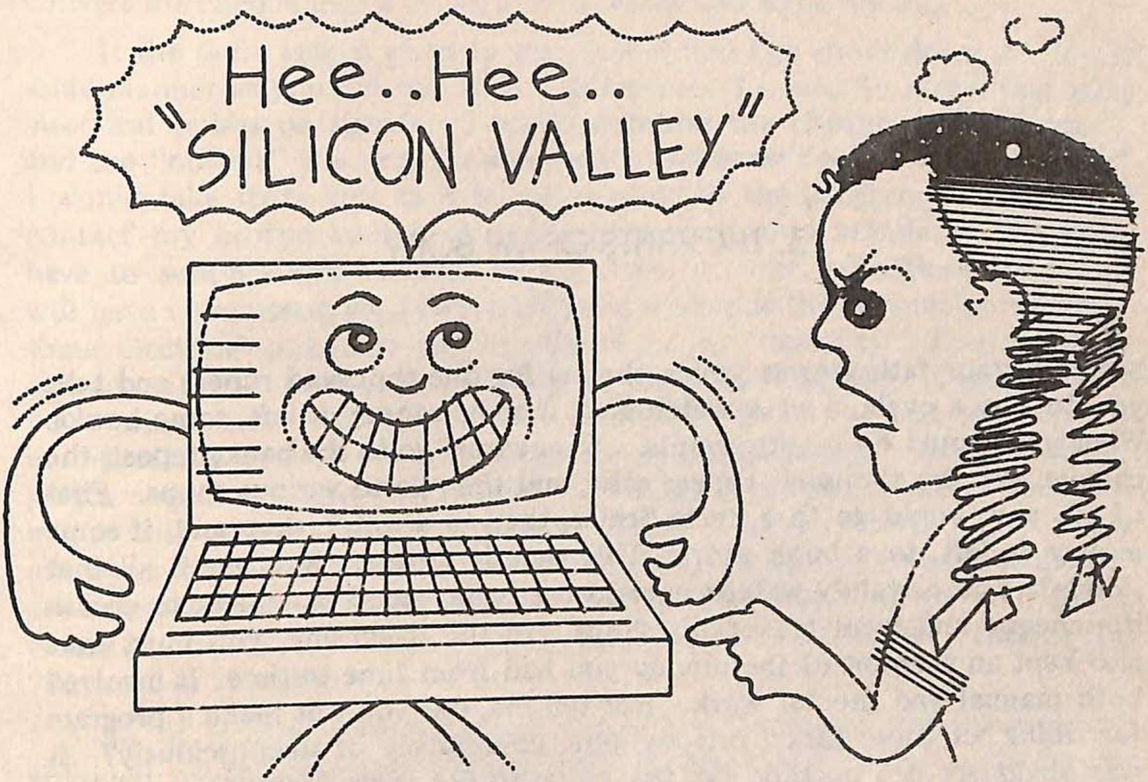
"So, Neha, how do you find this history of my development?"

"It is interesting", Neha typed out.

"Do you have any questions, Neha?"

"Yes, there is one question. I have heard there is Silicon Valley in the U.S.A. where chips are manufactured on a large scale. Please tell me something about it."

"If you examine the map of the U.S.A., you will find no such region there! 'Silicon Valley' is a name only known in the computer community. It actually refers to a valley region called 'Palo Alto' in California. It was



William Shockley, the co-inventor of transistor, who first went to Palo Alto to establish a firm for the manufacture of transistors. He took along with him his best forty students. Although he himself was not successful in his enterprise, his students stayed on and raised a number of companies there to manufacture chips. As silicon is the basic material used for making chips and is therefore widely used in Palo Alto, somebody called the place 'Silicon Valley'. The name stuck on and became a part of everyday language. It is a beautiful name – is it not? Any more questions, Neha?

"None. . . . ."

"Now, let me go on to the real thing – how do computers function . . . ."

3. THE PARTS OF MY BODY

Suppose your father gives you a cheque for one thousand rupees and tells you to buy a cycle, a wrist watch and, if some money is left, some books. What you would do is very simple. You would go to the bank, deposit the cheque, get the thousand rupees cash, and then go to various shops. First of all, you would go to a cycle dealer, then to a watch shop and, if some money is left, to a book shop. This sounds simple. But was it all that simple? You certainly walked over to the bank, stood in a queue to encash the cheque and went to various shops. In the meantime, you must have also kept an account of the money you had from time to time. It involved both manual and mental work. But tell me, did you not make a program for doing all these tasks, one by one, consciously or unconsciously? It was obviously not possible for you to go to the cycle dealer first and buy a cycle without money. Nor was it possible for you to go to the book shop first after drawing the money from the bank just because you love books the most. You did not do this because you were not sure how much money would be left after buying a cycle and a wrist watch. In other words, you set

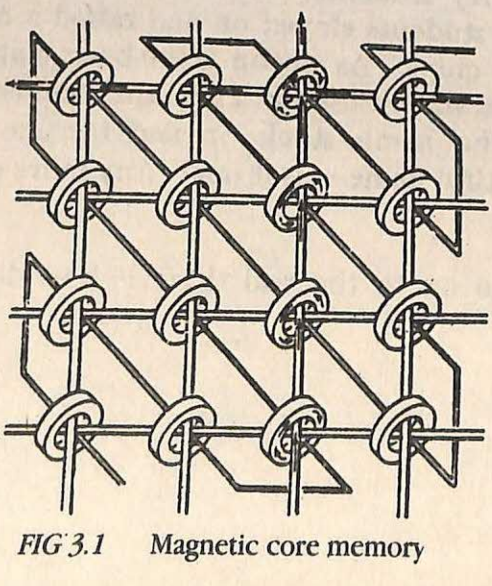


FIG 3.1 Magnetic core memory

up a program and then conducted all tasks or operations accordingly to convert the cheque into a cycle, a wrist watch and some books.

If the same task is given to me, how would I go about doing it? In the same manner as you did but with a difference. I would do everything using electrical pulses or signals. I would consider the cheque as the "input", and the "output" is a cycle, a wrist watch and some books. The "program" I would take from you as it is. According to the program, I would first contact my brother-computer in the bank through a telephone line (You have to suppose this because in the days to come, all offices and shops will have computers; see Section XII) and withdraw the amount of money — some electrical pulses — and transfer it to my "memory". Then I would contact my computer-brother in the cycle dealer's office. It would show you various models of cycles on my screen. When you had selected the model of the cycle I would transfer the required money — some electrical pulses – to that computer-brother. The same procedure would be followed in the case of buying a wrist watch. There I would calculate how much money is left and depending upon the books you prefer, I would make the necessary transfer of money to the computer-brother. All of your goods would be delivered to you at your doorsteps in due course. That is the "output" of the program.

So, it is clear that you had designed a "program" for me and also provided me the necessary money. The money is the "data" -- the figures which I handled from time to time. I followed the program step by step, did some mathematical calculations with the data as and when it was necessary, used some logic to buy the books you wanted within the available money, and provided you with what you wanted—all through handling and transferring electrical pulses. That is what all computers do, however big or small.

I must however tell you that I divide the task given to me strictly into various portions. I allot each portion to a part of my body which is designed to do that work. This is nothing extraordinary because you also work the same way. You do not, for instance, use your chest to pick up a book! Obviously, you use your hands. Each part of your body is designed to do a particular kind of task. I have five main parts (Fig. 3.2) :

(i) Input Device
(ii) Control Unit
(iii) Arithmetic and Logic Unit
(iv) Memory Unit
(v) Output Device

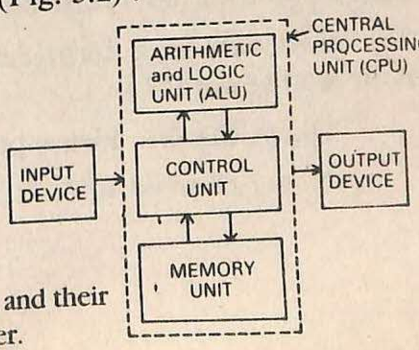


FIG 3.2 The various parts of a computer and their interconnections with each other.

Control Unit, Arithmetic and Logic Unit (ALU) and Memory Unit are often treated as one single unit called "Central Processor Unit" (CPU). When a task is given to me, this Central Processor Unit performs it. It then becomes extremely busy. Electrical pulses are continuously exchanged among its three units. Just imagine that millions of electrical pulses are exchanged among these parts of mine within a matter of a fraction of a second to perform a task! Your brain also does something similar at a slower speed, of course, but you are not conscious of it!

What are exactly these separate parts of mine, how does each function and how is a given task completed? Before I discuss all this, let me make one very basic thing clear to you. When you made a program for buying the cycle, etc, you must have first thought about it. And you must have thought about it in a language with which you are familiar. It could be Hindi, English or any regional language. Even otherwise, when you ask somebody to do a task for you, you talk to him in some language with which that person is familiar. But my language consists of electrical pulses. How can you talk to me in that language? Scientists and inventors have therefore developed languages which are neither yours nor mine. They are, however, comparatively close to the most commonly understood language, which is English. They are known as "computer languages". Today, there are a large number of them (see Section VIII) which are used for various purposes.

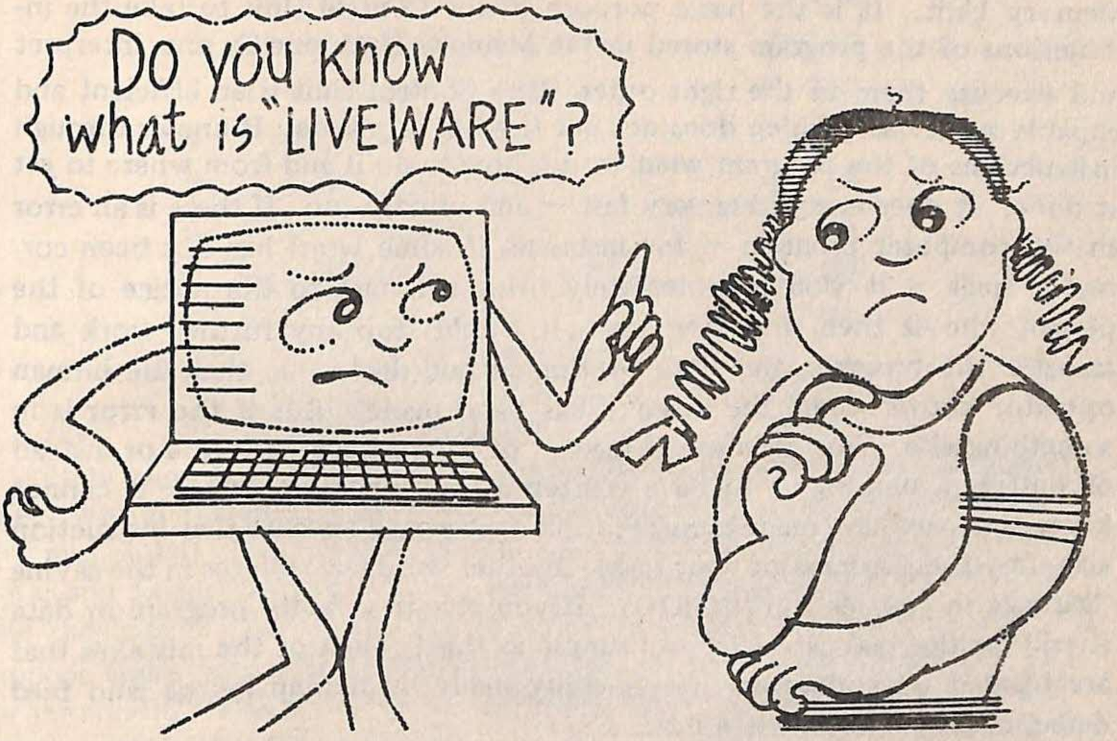
The program, which is obviously written in one computer language or the other, is known as "software". It does not require more than a paper, pencil and a thorough knowledge of languages to produce a software for a particular task. In recent times, however, one does not need to produce one's own software. It can easily be bought from the market. The result is that one need not have a thorough grasp of my languages or programming to operate me for a particular task. On the other hand, "hardware" is what you often take me for — the machine. And, Neha, by the way, do you know what is known as "liveware"?

Neha was taken aback by this question. She typed in a moment later. "No, I don't know. Please tell me about it."

"Liveware is a term referred to people who work with computers. Your are liveware!"

"Okay, thanks. Please proceed." Neha typed out, a bit annoyed.

"Now I proceed to discuss my various parts."



Input Device: The program and data is fed into me through an input device. The foremost function of the device is to convert the language of the program and data into electrical pulses which I can understand.

There are various types of input devices. You have to give your task to me through one of them. It could be punched cards or tapes, a Visual Display Unit (VDU), etc (see Section IV). Unfortunately, a large number of persons think that this input device and its companion, the output device, are the most important parts of me because they are the ones in the lime-light — exposed to the outside world. You can imagine how unhappy I feel, because these devices are simply like translators between you and me as we do not know each other's language. It is the Central Processor Unit which performs your entire task. So, do not take this screen and the key-board for me. It will be like taking the outer appearances of a person for what he is in reality.

Control Unit: After the translation of the program and data into electrical pulses at the input device, the Control Unit transfers them to the

Memory Unit. It is the basic purpose of the Control Unit to take the instructions of the program stored in the Memory Unit, one by one, interpret and execute them in the right order. The Control Unit is an efficient and capable supervisor, which does not get tired at any time. It knows through instructions of the program what to do, how to do it and from where to get it done. It does everything very fast — and blindly too. If there is an error in the computer program — for instance, if some word has not been correctly spelt — it would immediately bring this fact to the notice of the person who is then operating me. It would stop any further work and transfer the program and data to the output device, so that the human operator knows where the mistake has been made. But if the error is in something else — for instance, if instead of 2 you have written 4 or instead of putting a plus sign you have written a multiplication sign — it cannot know that you have made a mistake and so it would execute that instruction also, and make a mess of your task! In other words, it believes in the saying "garbage in garbage out" (GIGO). If you give in a faulty program or data it will do the task wrongly. As simple as that! Most of the mistakes that are blamed on computers are generally made by human beings who feed defective programs and data into us.

When a task has been performed, the Control Unit transfers the results stored in the Memory Unit to the output device, which, of course, is again an instruction in the program itself. So, when you gave the task of buying the cycle, wrist watch etc, from the cheque, it is this Control Unit which executed your task.

Arithmetic and Logic Unit: When I withdraw money from my brother-computer in the bank and transferred it to the cycle dealer, wrist watch company or book shop, all the necessary additions and subtractions — the mathematical calculations — were performed in the Arithmetic Unit. When the questions arose as to the selection of books from the book shop within the money left it was again in the Logic Unit the decision was taken. As both the mathematical and logical decisions are interconnected, both of them are executed in this combined Arithmetic and Logic Unit. Let me explain this in detail by taking the above purchase of books we made.

Suppose Rs 150 were left after buying the cycle and wrist watch. Now you had given me a list of books in the order of your interest. I requested my brother-computer in the book shop to tell me the price of each book. It gives me, say, the following information:

1.	Network Revolution	Rs 100
2.	The Worldly Philosophers	Rs 160
3.	The Andromeda Strain	Rs 150
4.	Great Expectations	Rs 30
5.	Computer Pioneers	Rs 10
6.	Delhi Guide map	Rs 5
7.	Scientists of India	Rs 20
8.	Great Discoveries	Rs 25
9.	A Guide to Bird-watching	Rs 120
10.	A Book of Nonsense	Rs 200

Now book 1 can be bought because its price is within the money available. Within the remaining Rs 50 only books 4, 5 and 6 can be bought. The money left after the purchase is Rs 5. You can see that the Arithmetic and Logic Unit had not only to do additions and subtractions but also take the logical decision of buying books 4, 5 and 6 after buying book 1. Suppose there was no question of any priority list but you wanted to buy the maximum number of books within Rs 150. Then by a step by step process, using logic and arithmetic, I would have bought books 1, 6, 7 and 8. If you wanted to buy the most expensive book, I could have told you to buy book 3 because you had only Rs 150. Buying books 2 and 10 were beyond your means.

So, although the job of ordering for books, etc, would be done by the Control Unit, the basic mathematical and logical work is done by Arithmetic and Logic Unit using electrical pulses. How does it do this work? Well, it uses a type of mathematics known as "binary mathematics" and some electrical circuits known as "logic circuits" (See Section V and VI).

Memory Unit: When you went to the cycle dealer, you knew how much money was in your pocket, and so also when you bought the wrist watch and books. Your memory kept an account of the money you had in your pocket. Likewise, when I have to perform a task, I keep certain things in my Memory Unit, which I withdraw from it as and when they are needed. In fact, as soon as a program and data are fed into the input device, the Control Unit transfers everything to the Memory Unit. Thereafter, the Control Unit withdraws the instruction one by one and the data at the time of requirement. When the Control Unit knows that a particular instruction has been executed by the Arithemetic and Logic Unit and some results have come forth, it transfers the same to the Memory Unit immedi-

ately. If the results are to be used again in subsequent calculations or decisions, they are again withdrawn and transferred to the Arithmetic and Logic Unit for further action. Otherwise, the results stay in the Memory Unit until the task is completed. The results are then transferred to the output device which prints or displays them.

From the above discussion, you can see that the Memory Unit is used for storing programs and data at various stages of the performance of the task and for various purposes. Therefore, a Memory Unit consists of several types of memories. For instance, one type of memory is for storing instructions of the program before they are executed. Another type of memory is for keeping final results, and so on (see Section VI). But you should keep in mind the fact that the Memory Unit performs its function of "memorising" only until the task is complete. Once the task is over, the Memory Unit is a "clean slate" again — ready for the next task. There are however some devices also what are known as "storage devices" (Section IV), which can store any kind of information permanently for use at a later date. In other words, these devices act as additional memories to the Memory Unit as and when a task demands. In my own example, a storage device could be used for keeping the list of books that you wanted me to buy because I do not keep any such lists in my Memory Unit. To avoid any confusion, from now onwards I shall call the memory in the computer as the Main Memory Unit.

Output Device: Once the program is over, results are expected. It is the purpose of the output device to translate the electrical pulses of the results into a language understandable by human beings. This can be done in several ways. The results could be printed on long rolls of paper, or displayed on a TV-like screen, or recorded on a microfilm or magnetic tape for future use (see Section IV). In the near future, I may even be able to announce the results of your task, as judges do every day in court rooms. I would be more pleasant in my tone, of course. And in case you do not want to listen to the results, you will say, "Shut up, will you!" I will then keep shut, and tell you the results only when you are in good mood, or when you are free.

"Do you have any questions Neha?"

"No! Please proceed," she typed out.

4. MY ASSISTANTS

The Central Processor Unit, which is composed of Arithmetic and Logic Unit, and Main Memory Unit, is the brain and heart of a computer, no matter the type. However, although the brain and heart are the most crucial organs of the body of a human being, the assistance of other organs of the body is also needed. Is it not so? In the same manner, the Central Processor Unit needs the assistance of some devices to show its ingenuity and skills. These devices are known as "peripheral devices" because their tasks are peripheral — not central to the working of a computer. These devices are mainly three: input device, output device and backing store.

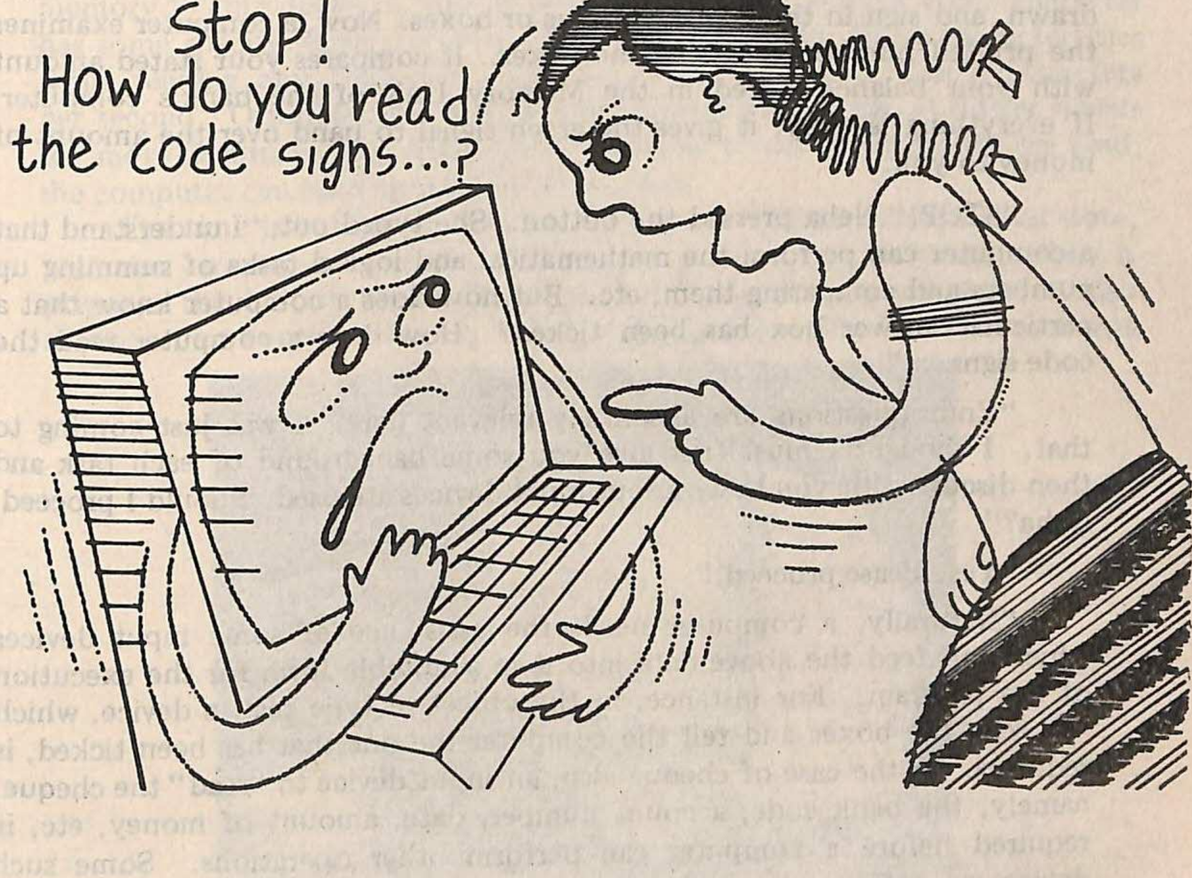
Through an input device data and program are fed into the Central Processor Unit. It is, in fact, the medium through which a human being communicates with the Central Processor Unit. As both the human being and the Central Processor Unit cannot communicate directly with each other due to the difference in their languages, the input device acts as an interpreter or translator to convey the data and program of a human being to the Central Processor Unit. Similarly, through an output device the Central Processor Unit conveys the results arrived at, in a language which human beings understand. Even today, this human being-to-Central Processor Unit communication or "man-to-machine" communication is not convenient. Let us hope that we will be able to communicate with each other more effectively in the near future.

"Backing store", as the very name implies, is the memory storage device made available to a Central Processor Unit. It is used for storing some specific data or program permanently for future use. There are today available a wide variety of these peripheral devices for the simple reason that the computer is being used in diverse walks of life. Most of these devices are discussed below.

The oldest type of input device but still in use is the "punched cards or paper tape". The computer pioneer Herman Hollerith used this type of input device for his machine around the turn of the last century. Nowadays, each card is of a standard size and each one carries one instruction or step of a program. You have to employ a typewriter-like keyboard device to punch your instruction on the card (See Fig. 1.7). The card is divided into 80 columns and 12 rows. Each column is for one character, a letter, numeral or sign, of the instruction, which is written in a computer language. When you punch a character on the keyboard device, one or more holes are punched in the 12 places of the column. The number of holes and their positions in the column represent the character being punched. If the characters (including spaces) in one instruction are more than the 80 columns available on the card, you can carry over the instruction to the next card using some code language to indicate that you have done so.

The bunch of cards, which is your program, is then placed in a device called "Hopper". The Hopper holds the cards and then passes them one by one to the machine called "Card Reader". The Card Reader literally reads the cards and translates them into the language of computers — electrical pulses or bits. It reads cards at the rate of about 2,000 cards per minute. This may appear to be a fantastic speed but it is very slow for a modern computer like me. Punched tape is also used in the same manner and has almost the same speed. The tape is generally 2.5 centimetre in width. It is available in rolls, and can be of any length depending on the program. Not so widely used as punched cards, it is nevertheless preferred in some business dealings and terminals.

Nowadays, computers are being widely used to perform some routine yet essential tasks. For instance, computers are being used for the preparation of bills of various products — from water and electricity to cars, in the execution of bank dealings, in booking tickets for trains, buses and aeroplanes, in research survey work, in checking papers and preparing mark sheets, etc. Let me discuss the last application first because you are most familiar with it. Nowadays, objective type tests are often employed in schools, colleges and universities to judge the level of understanding of students. You are handed printed sheets of the test paper in which questions



are asked. In front of every question are mentioned several answers, each ending with a square box. You have to tick the right answer in one of the boxes. When all the sheets are collected from the students, they are fed as such into a computer. The computer compares the tick-marked answer with the right one stored in its Memory Unit. If the answer is right, marks are awarded and stored. If the answer is wrong, the next question is examined, and so on. When all the questions have been examined, the marks stored in the Memory Unit are added up to give the total. It is promptly printed under the appropriate subject column in the mark sheet of the student.

Now, take the case of encashing money from computerised bank through a cheque. If you care to examine a cheque, you see several numbers printed on it. The numbers are the code signs of the bank and your account number in the bank. You fill in the date, the amount of money to be withdrawn, and sign in the allotted spaces or boxes. Now, a computer examines the printed numbers and also the boxes. It compares your stated amount with your balance stored in the Memory Unit of the bank's computer. If everything is okay, it gives the green signal to hand over the amount of money to you.

"STOP!" Neha pressed the button. She typed out, "I understand that a computer can perform the mathematical and logical tasks of summing up numbers and comparing them, etc. But how does a computer know that a particular answer box has been ticked? How does a computer read the code signs. . ."

"Your questions are absolutely relevant here. I was just coming to that. I thought I must first give you some background of each task and then discuss with you how various input devices are used. Should I proceed, Neha?"

"Yes, please proceed."

"Naturally, a computer needs the assistance of some input devices which can feed the above data into it in a suitable form for the execution of the program. For instance, in the objective type test, a device, which can scan the boxes and tell the computer the one that has been ticked, is required. In the case of cheque also, an input device to "read" the cheque, namely, the bank code, account number, date, amount of money, etc, is required before a computer can perform other operations. Some such devices are as follows.

"Mark Sense Reading" devices can sense a tick mark in a box. One type of such device senses the electrical conductivity of the pencil lead and so records the mark. Another type senses the mark by passing light through the boxes. In the latter case, the tick-marking instrument can be a pencil, pen, or a sketch pen. For using "Magnetised Ink Character Recognition" (MICR) device, a special type of ink, which contains magnetised particles, is employed in writing anything, say, on a cheque. In fact, all the standard details, namely, the bank code, account number, etc, are pre-printed on the cheque book before it is handed over to you. The magnetised particles induce electric current in the device and thus enable it to "read" the details. In fact, it can even read an over-stamped detail. The speed of reading of such a device is 1,200 documents per minute!

In "Optical Character Recognition" (OCR) device, every character, whether it is a letter, a number or a sign, is assumed to be composed of a collection of minute dots and then "read". A light beam scans the characters and matches the arrangement of dots with the ones it has in its memory. This device is able to read a character because every character has some specific characteristics. The device looks for those characteristics while reading any character. The device can read upto 2,400 characters per second. Often, all the devices mentioned above are run at slower speeds for more accuracy. So, once the tick-marked boxes or characters are read, the computer can take up the rest of the task.

The time is not far away when a shop, including a departmental store, will also employ a computer. A computer serves two purposes: while it prepares the bill of the product you have bought from the shop, it also makes an appropriate entry in the "stock register". The latter entry keeps

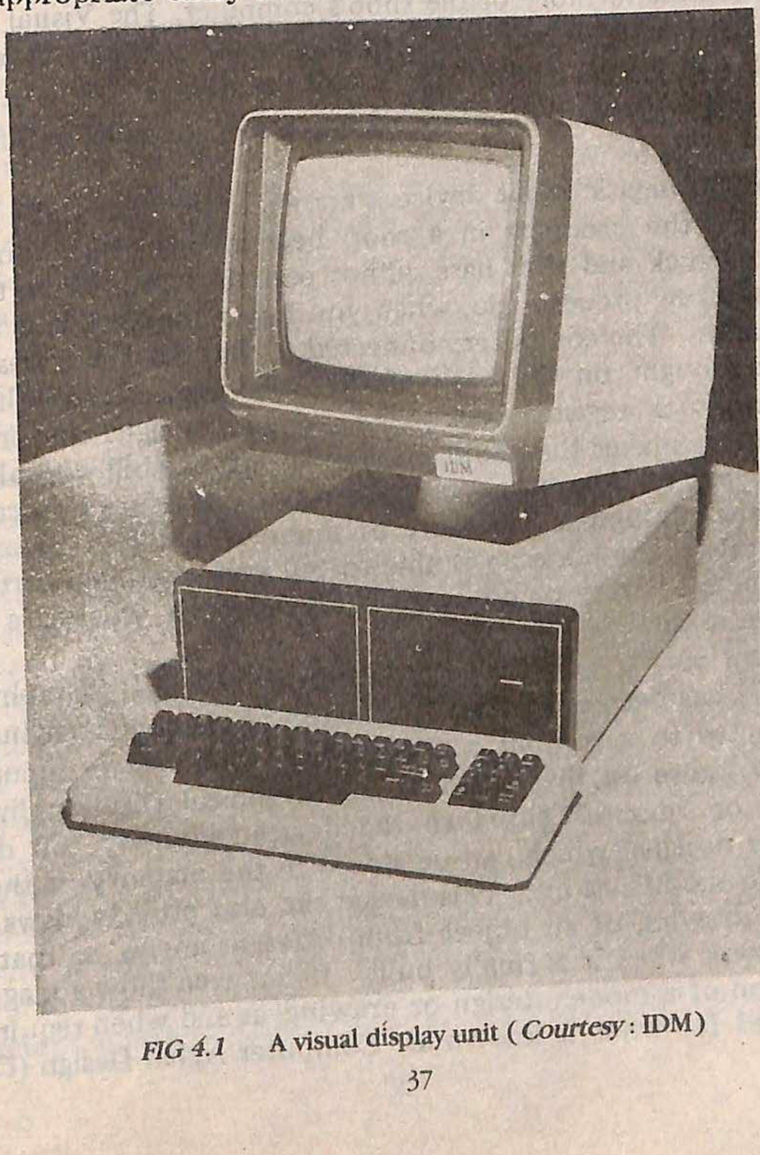


FIG 4.1 A visual display unit (*Courtesy*: IDM)

the incharge of the stock informed about the number of that product sold and the number available in the stock at the press of a button. If the incharge finds a particular product going out of stock, he then orders for it from the manufacturer. In short, the computer makes things easier both for the buyer and shop incharge. But, again, how does such a thing become possible? The computer has to employ a variety of input devices for this purpose.

The simplest is a "Visual Display Unit (VDU)," which has a keyboard and a display screen as you presently have. On the keyboard the shop assistant types in the products you have bought and their prices, which promptly appear on the screen. On the press of button, the grand total of the amount is made and printed on the bill with all details for payment. At the same time, the appropriate entries about the purchases are made in the stock register held in the memory of the shop's computer. The Visual Display Unit is nowadays becoming increasingly popular in the commercial world because it has the biggest advantage of displaying the data before it is fed into the computer. Any error can therefore be corrected immediately after it is seen on the display screen.

A more automatic input device is known as the "Bar Code Recognition System". All the products in a shop bear a code mark composed of a collection of thick and thin bars, either pasted or printed on them during the manufacturing process. So, when you buy a product, it is run under a bar code reader. The computer connected to the Bar Code Reader records the product bought on the basis of the code mark, makes the necessary entry in the stock register kept in its memory, assigns the price to each product bought, makes the grand total and prints the bill with all the details for your payment. The entire procedure is over before you can bat your eyelid. Such a system is especially of immense use in a library. At the press of a button, the librarian is able to tell you whether a particular book is available in the library or not; if it has been issued, when it is likely to be returned, and so on.

In recent times, a new type of input device called "Graphical Display Unit" (GDU) has been developed for the use of architects, engineers, artists, etc. Connected to a computer, this device is used as an input device for drawing any figure on the screen of the Graphical Display Unit. Using a "light pen" or "mouse" fitted to the device, anybody can draw graphs or figures or designs, which can be stored in the memory of the computer after suitable modifications. This device can also provide views of a three-dimensional drawing of an object from different angles, so that you know how it will look when it is finally built. It can even show a magnified form of any section of a model, design or drawing, as and when required. Such a device is used for what is known as "Computer Aided Design (CAD)." Any

design or drawing can be displayed when required on the screen repeatedly in colour or black and white. In other words, like the Visual Display Unit, this device also acts like an output device.

The device which is however likely to be used widely for recording data, while a human being can also have a free movement, is the "Voice Input". Such a device will be most beneficially used in factories. Nowadays it is being used at some airports in western countries to sort baggage for various destinations. Using a limited vocabulary, a person can impart instructions orally to the computer through this device. Of course, the computer can recognise the voice of anybody other than its operator to avoid the possibility of its misuse by any one. This device is yet to be perfected. In the days to come, it will certainly be used on a large scale because you human beings prefer talking to anything else!

Output Device

It is quite natural that when you feed data and program into an input device, you want the results of the task in a suitable form. For instance, when you have fed the data and program for the preparation of mark sheets, you want that the results of all the students should appear in printed form on separate mark sheets. If you have fed the technical design of an item into a Graphical Display Unit, you want it in a printed form. If you are busy with something and you have no time to look at a printed sheet or a Visual Display Unit, you would like to be informed about the results of a task by a voice, and so on.

There are various types of devices called "printers", which can print results. Some printers print one line at a time at a speed of 300—2,500 lines per minute and others print one character at a time, about 20—50 characters in a minute. Each is selected as the task demands. In recent years, a highly fast but expensive "Laser Printer", which can print 30—250 pages per minute, has been developed. The quality of the print is good and a wide selection of character fonts is available. "Liquid Crystal Displays" (LCD) and "Light Emitting Diodes" (LED) are often used these days for the direct display of results in instruments, calculators and video-games. Apart from the visual display units and graphical display units, which can exhibit their outputs on their screens and also in printed forms, a "Computer Output Microfilm"(COM) (see below) can also be employed to transfer your output results, whether it is a text, drawing or graph, on to films which can be viewed at leisure at any future date. In the case of voice output, you have to ask a question to the device, which will trigger off an answer. As this device has at present limited vocabulary, it is used for single purposes and tasks

which demand routine answers, such as the flight or train timings at an airport or railway station, the availability of a product in a departmental store, etc.

Terminals

An input or output device is called a"terminal"when it is at a remote distance from its Central Processor Unit. It is connected to the Unit via a cable, telephone or telegraph wires, or radio waves. Nowadays, a Visual Display Unit, which is both an input and an output device, is commonly used as a terminal. In fact, the device which you are presently handling is a Visual Display Unit terminal.

In recent years, a hand-held terminal, the size of a pocket calculator, has found applications in several fields. Carrying this terminal in his bag, a person can feed his data into it on the spot as he goes on his rounds. For instance, a salesman can feed the orders he has secured for his company's products; a survey researcher the varied data he has collected in a village; a meter reader all the readings as he moves from one house to another, and so on. Of course, the data is stored in the Memory Unit of the terminal and can later be transferred to the main memory of a computer for further action.

In recent times, "intelligent terminals" are also making their entry into the market. These terminals are called so because they need not be connected to a Central Processor Unit for small tasks. They themselves have a microprocessor to perform small tasks. It is only when the volume of data of program is too high that terminal is connected to a Central Processor Unit.

Backing Store

You are well aware that a computer has its own main memory unit which is used for storing data and program while a task is in progress. But, often, additional memory storage units are required for performing tasks of commercial or scientific interests. These external memory storage units are called "Backing Store." A memory storage unit is also used as a source of additional data required in the task. For instance, a subscriber's list of a magazine can be stored on a memory storage unit. As and when the copies of the magazine are to be posted, the memory storage unit is consulted and a list is prepared for the dispatch of the copies. Such a memory storage of subscriber's list can also be used for various other tasks, such as, sending reminders to subscribers, sending "special offer" coupons to them, etc.

In recent times, however, such memory storage units are also used for storing program due to several reasons. For instance, if a human being is feeding a program into a computer via a terminal or punched cards, it is necessarily a slow process. Similarly, when the output device is displaying or printing the results of a task, it is a slow process. The Central Processor Unit should not be kept idling all this time. So, the program is first stored on a memory storage unit which is then fed into the Central Processor Unit for a fast transfer of the program. Or, the Central Processor Unit first transfers the results to the memory storage unit which is then connected to a printer. Computer-time is thus saved.

Backing store devices are often made up of magnetic materials. Data or program are stored in them in the form of magnetic spots. These devices are of two types: (a) Serial access and (b) Direct access. The difference between these two types of devices is similar to the difference between a tape-recorder cassette and a gramophone record. For listening to a particular song on a cassette, you have to listen to all the songs serially preceding that song or wind the tape up to that song. But in case of a record, you can directly keep the needle of the gramophone arm right where that song begins. In other words, in "serial access" memory, the data or program stored on it can be retrieved or recalled only in the order in which it was stored. On the other hand, in the "direct access" memory, data or program can be retrieved or recalled from any point directly without wasting time in searching through the entire memory. Direct access saves computer-time and is therefore usually preferred.

A "magnetic tape" is a serial access memory device. 226-2500 characters can be stored on the tape per centimeter. It is also cheap and efficient. The data or program stored on it can be erased and replaced by new ones, just as it is done in a tape recorder. However, in most walks of life you need a particular item of information immediately and so direct access memory devices are more useful. There have therefore appeared a variety of direct access memory devices in the market, each having specific characteristics and each employed according to the task to be performed. A "Magnetic Disk Drive" is like a gramophone. Data or programs are stored along the concentric circles of the magnetic disk, similar to a record. The disc is however divided into several sectors for easy access to the data stored on it. As and when a datum is to be retrieved from the disk, the sector and location address is mentioned to trace it. Often, there is not one disk but six or more disks spinning about a common hub in the drive. In some devices, these disks are fixed and in others they are removable within a few seconds. These devices have high storage capacities.

A *Floppy Disk Drive*, a direct access device, is nowadays very popular for two reasons. Firstly, the floppy disk is cheaper and secondly, faster to replace than the magnetic disk. It is nowadays available in three sizes: eight inches disk, five and one-fourth inches mini-floppy disk and three and a half inches micro-floppy disk. Owing to its relatively small storage capacity, it is often used in personal computers and small business computers. Another direct access device is a sophisticated version of floppy disk. It is the *Winchester Disk* which is an air-tight and specially lubricated disk to prevent dust and reduce friction. It is therefore highly reliable, accurate and fast. Nonetheless, it is cheaper than a magnetic disk and requires no maintenance.

In recent times, a new type of memory storage device called "Laser Card" has entered the western market. In this device, data and program are stored in the form of pits on a special film made by a laser, a highly uniform and powerful light. A laser reader can only "read" the data or program stored on the film. At present, these devices have one disadvantage. Once anything is stored on a film it cannot be erased. So, these devices can only be used where something has to be stored permanently. Meanwhile, efforts to increase the memory capacity of these devices continue.

MICROFICHE

A microfiche is yet another device which can permanently store some data or results or pictures that a computer produces. They could be important office secrets, results of a scientific experiment or design of a house, etc. They are often stored on very small photo films, 16 or 35 mm in size, called "microfiche" thus saving paper and storage space. The "Computer Output Microfilm" (COM) is employed for this purpose. Frame by frame, a computer can directly transfer the results, data or pictures it has generated to this device. When you want to consult the microfiche, you have to use an inexpensive "desk-top microfiche reader" to view the data, pictures or results. If you desire, you can also get a printed copy of a particular frame of microfiche at the press of a button. This device differs from all the above storage devices in the sense that it stores information in a form directly comprehensible to human beings. Do you have any questions, Neha?"

"None. Please proceed."

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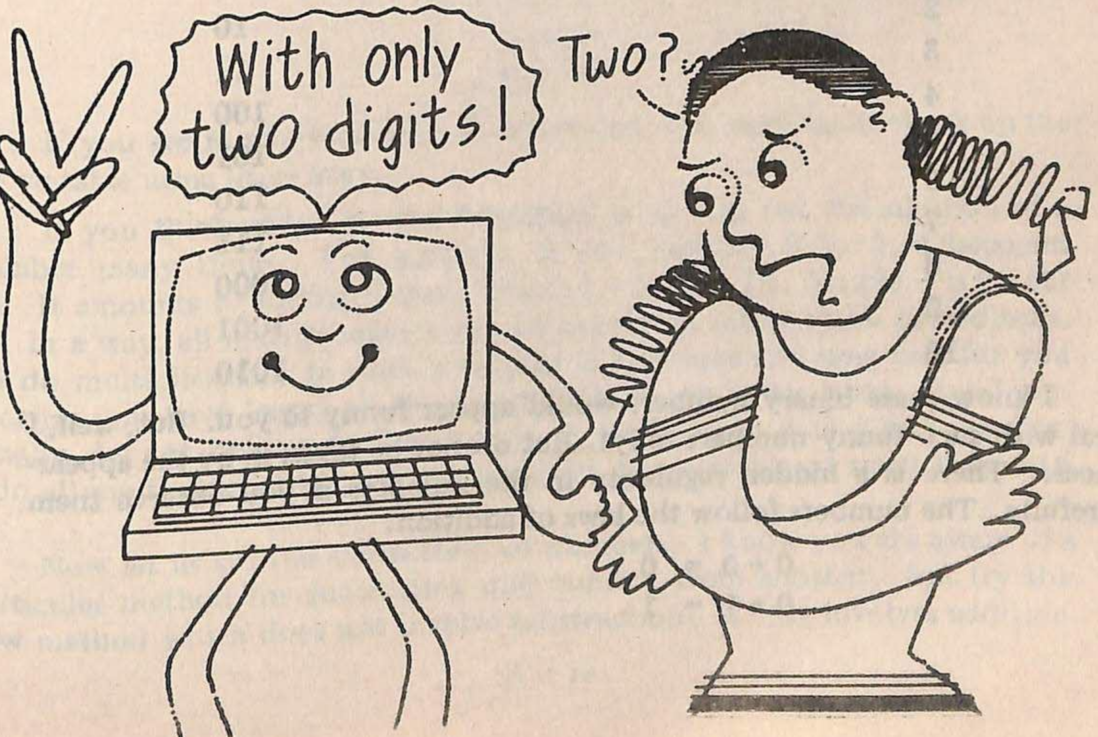
FIG. 4.2 Bar Code at the back of a book

5. I WORK BY ELECTRIC PULSES, MATHEMATICS AND SWITCHES

Electric pulses! Yes, they mean life to me! When they run through me, I feel alive and energetic. No electric pulses means no life! Now I will discuss how the pulses exactly execute various tasks given to me. What are the various types of circuits inside me that enable them to perform various tasks? Frankly speaking, it is not so easy to understand my working thoroughly. But it is not difficult for you to get a glimpse of how I work.

Binary Mathematics

You may be wondering why I am discussing binary mathematics when I should be talking about my life and soul — the electric pulses. I am discussing this novel type of mathematics because electric pulses simulate its laws



and rules. In binary mathematics, there are only two digits: 0 and 1. This may sound odd to you because you are familiar with decimal mathematics which involves ten digits, namely, 0,1,2,3,4. . . .8 and 9. But you will be surprised to know that some tribals of Australia and South America and bushmen of Africa have been using binary mathematics for counting purposes from ancient times, although it is a hard way to count. Perhaps you find decimal numbers easy because your hands have ten fingers, including thumbs. I find decimal numbers too cumbersome and tedious because one has to handle ten different digits. Binary mathematics is much more convenient and easy because it deals with only two digits. Moreover, as you will soon notice, all the mathematical operations such as multiplication, division, etc, can be reduced to only one type of operation — addition. All of my marvellous qualities such as fantastic calculating speed can only be attributed to my speed of doing additions. But, lo! I have let out my secret! Please keep this to yourself only. Otherwise, if everybody comes to know about it, nobody will respect me any more.

I will first show you what binary mathematics is in terms of decimal mathematics because you are unfamiliar with it. Table I shows you your ten digits in terms of only 0 and 1.

Table 1

Decimal number	***Binary equivalent***
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010

I know these binary numbers would appear funny to you. But, well, I deal with such funny numbers only! But do not be taken in by the appearances. There is a hidden regularity in the numbers if you observe them carefully. The numbers follow the laws of addition:

$$0 + 0 = 0$$
$$0 + 1 = 1$$

$$1 + 0 = 1$$
$$1 + 1 = 10$$

If you are not convinced, you better check up the additions in the above table.

Now, you may wonder what these binary numbers are. What do they really mean? The binary numbers represent the powers of 2, just as your decimal numbers represent the powers of ten. For instance, take a number of decimal mathematics.

12650 can be shown to be basically consisting of other numbers in the powers of ten.

$$12650 = 10000 + 2000 + 600 + 50 + 0$$
$$= 1 \times 10^4 + 2 \times 10^3 + 6 \times 10^2 + 5 \times 10^1 + 0 \times 10^0$$

Similarly, a binary number can be shown as:

$$1001 = 1 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$$
$$= 8 + 0 + 0 + 1$$
$$= 9$$

You can easily see that there are also some basic laws of multiplication in binary mathematics. Here they are:

$$0 \times 0 = 0$$
$$0 \times 1 = 0$$
$$1 \times 0 = 0$$
$$1 \times 1 = 1$$

If you are in any way not yet convinced, you may again check up the above table using these laws.

If you think about it, multiplication is nothing but the addition of a number many times. For instance, if you multiply 5 by 3, it becomes 15. It amounts to adding 5 three times: 5 + 5 + 5 = 15. Simple — is it not? So, in a way, all multiplications can be converted into a series of additons. To do multiplications in such a manner is a tedious and long task for you because you havé learnt all the multiplication tables by heart. But I personally do not believe in learning by heart because it is a bad practice. I do all multiplications by adding numbers, however big or small they may be.

Now let us see the subtraction of numbers. I know you are aware of a particular method for subtracting one number from another. But try this new method which does not involve substraction! It only involves addition.

Moreover, it has a what I would call tricky use in binary mathematics. First, take the case of subtraction in decimal mathematics. Suppose you have to find out 542 − 123. Add 999 to − 123. This operation is known as taking the complement of −123. The result of 999 − 123 is 876.

So 542 + 876 = 1418

Now, add first digit of the number to the last one.

1418 = 419

So, 542 − 123 = 419

Using the complementary method in binary mathematics,

1011 − 100 = 1011 + 011 = 1110

Complement

= 111

i.e. 1011 − 100 = 111

In the above, you have seen how in decimal mathematics, the complement of a number is obtained — just by adding to the number as many 9 as the number of digits it has. In binary mathematics, taking the complement of a number is very easy — just switch over to the other number! If the number is 1, its complement is 0, and vice versa. How this switching over to the other digit is performed can be seen in the next section.

Again, what is division of a number? It is nothing but subtraction of a number from another number many times. For instance, 48/4 = 12 is basically subtraction of twelve 4s from 48.

48 − (4x4x4x4x4x4x4x4x4x4x4x4) = 0

So, division is nothing but a series of subtractions, which, in turn, are nothing but series of complementations and additions. In short, all the mathematical calculations are for me nothing but additions and complementations! I can do both these operations very fast and accurately.

Often, binary numbers become very large in the sense the number of digits occupy a lot of space. Naturally, it is a burden on the storage space, whether in the memory unit or storage device. In such a case, I convert the large binary numbers into octal or hexadecimal system of mathematics. It will be sufficient to inform you here that in an octal system there are eight digits, namely, 0,1,2. . . . . 7 and in hexadecimal system sixteen digits, namely, 0,1,2,. . . 9, A,B,C,D,E and F e.g. a binary number 10110111 can be represented as 267 in octal system and the binary number 1100010100 10000000010110111111101 can be represented as C52016FD in hexadecimal system. So, you can imagine how I store big numbers of binary mathematics. It is easy, is it not Neha?"

"Yes, I never thought it was so easy," typed in Neha, who had crammed everything by heart. "Please proceed."

"I am happy that you are finding it so. Let me proceed to the next subject."

SWITCHES

You will recall how I was born. In the days of Charles Babbage, a calculating machine was a mechanical device. The gear teeth in it represented the two digits of a binary number. When its electrical version was built around World War II, pulses came into the picture. In those days, electric switches or electromagnetic or telephone relays generated electric pulses. Before I go any further, let me digress and tell you some elementary things about electric circuits.

A "circuit" means "complete one round"; for example, completing a circuit of a race course. An electric circuit is one in which electricity — a flow of electrically charged particles called "electrons" — runs from one end of a source, namely, battery, mains, etc, to its other and via a switch and any electrical or electronic gadget.

Take a simple case of an electric circuit. Apart from a battery as a source of electricity, it contains a switch and a bulb. This circuit is often shown in the following "short hand" form [Figs 5.1 (a) and (b)]

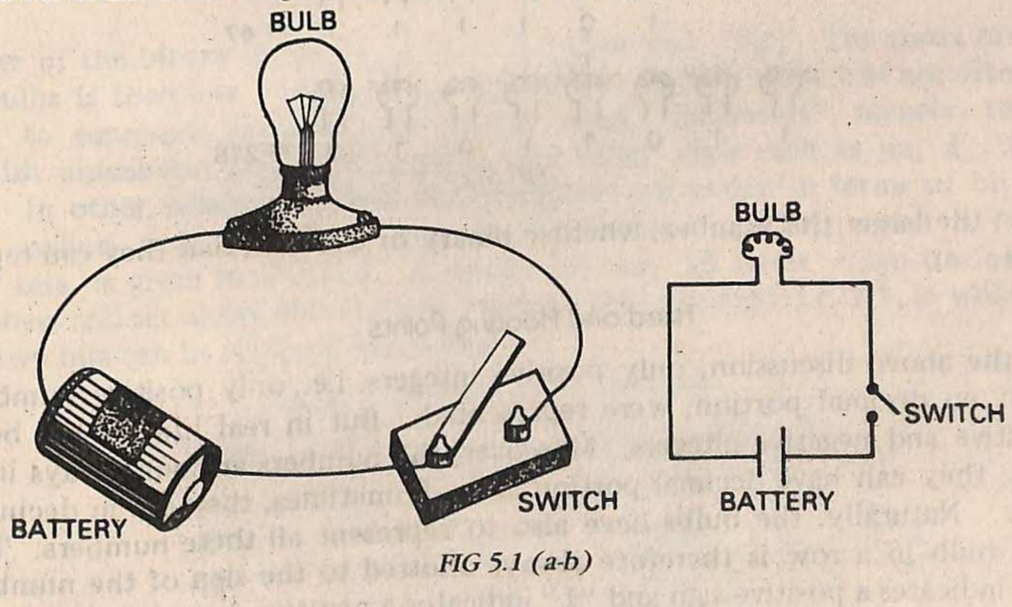


FIG 5.1 (a-b)

When the switch is "off", the circuit is not complete, and the bulb does not glow. On the other hand, when the switch is "on", the circuit is complete, and the bulb glows. Elementary — is it not?

Now, take the "off" bulb to represent the digit "0" and the glowing "on" bulb to represent the digit "1". In other words, when the switch is "off", the blub indicates the digit "0" and when the switch is "on", the bulb indicates "1" Use your imagination now. If there are a large number of bulbs, each a part of an electric circuit, does'nt the row of bulbs thus formed represent all the binary numbers?

For instance, in a row of eight bulbs as shown in Fig. 5.2 if only the first and fourth bulb from the right are glowing, the row represents 00001001. It is nothing but the number 9 of decimal mathematics. Similarly, by switching "on" certain other bulbs in the row, other binary numbers and thus decimal numbers are represented as shown.

It is obvious from Fig. 5.2 that the larger the number of bulbs in the row, the larger the number, whether binary or decimal, that they can represent.

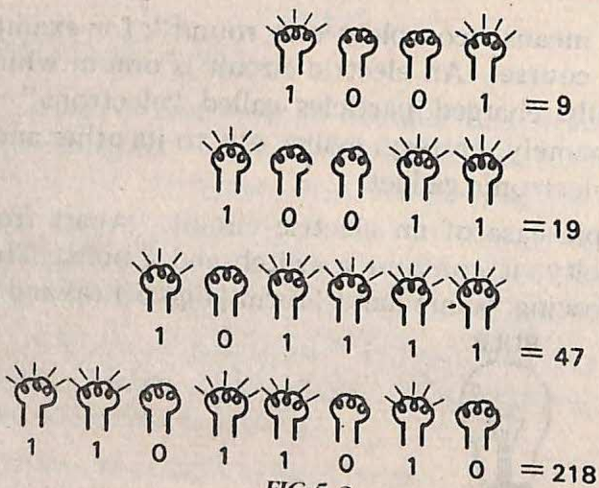


FIG 5.2

Fixed and Floating Points

In the above discussion, only positive integers, i.e., only positive numbers with no decimal portion, were represented. But in real life we use both positive and negative integers. Moreover, the numbers are not always integers; they can have decimal portion also. Sometimes, they are in decimals only. Naturally, the bulbs have also to represent all these numbers. The first bulb in a row is therefore always allotted to the sign of the number. "0" indicates a positive sign and "1" indicates a negative one.

Now, take two numbers with decimal portions, namely, 1.6875 and 0.721. If you want to add the two — or perform any kind of operation on them — you have to be very careful about the decimal point. While adding the two, for instance, you have to see that the decimal points fall one below the other. Then only you can add the two numbers. In their respective

binary representations, namely, 1.1011 and .10111, the same care has to be taken regarding the decimal points. In other words, you have to keep track of the decimal point every time an operation is performed or a decimal number is handled. Such a representation of a number is known as "fixed point representation". The number is known as "fixed point number".

For two small numbers, such a shifting of the decimal point is easy, but it is not so when several large numbers are to be handled in any manner. Then another method known as "floating point representation" is used. In fact, this type of representation is often used in most modern computers. Any number is first broken into two parts: its absolute, non-decimal part, and its exponential part.

1.6875 becomes $16875 \times 10^{-4} = 16875\ E^{-4}$

0.721 becomes $721 \times 10^{-3} = 721\ E^{-3}$ where E Stands for exponential

Handling such numbers electronically is convenient because each part can then be handled separately for performing any operation such as addition. Every part can also be stored separately.

Bits Bytes and Words

Either of the binary digits, i.e., 0 or 1, is known as a "Bit". The above row of bulbs is therefore composed of eight bits. In fact, eight bits are often used to represent numbers, as well as other "characters", namely, the English alphabets, punctuation signs, and other signs such as Rs, £, %, etc. In other words, numbers and characters are coded in terms of bits. The earliest code, called "Binary Coded Decimal" (BCD), which is for four bits, is given in Table 2. It codes for only 16 items — ten decimal numbers and six alphabets—because there are only 16 ways, i.e. 2^4, in which the two bits can be arranged for coding.

Table 2. Binary Coded Decimal

Items	Binary code
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110

7	0111
8	1000
9	1001
A	1010
B	1011
C	1100
D	1101
E	1110
F	1111

The fixed number of bits that are used as the code for a character or decimal number, which is the "bit-length", is called "Byte". In recent years, a computer often uses an 8 bit byte. In other words, there are 256 ways, i.e. 2^8, that the bits can be arranged to code for decimal numbers, alphabets, punctuation signs and other signs.

Table.3. EBCDIC representation of 0 to 9 and A to Z.

Character	Bit representation
0	1111 0000
1	1111 0001
2	1111 0010
3	1111 0011
4	1111 0100
5	1111 0101
6	1111 0110
7	1111 0111
8	1111 1000
9	1111 1001
A	1100 0001
B	1100 0010
C	1100 0011
D	1100 0100
E	1100 0101
F	1100 0110
G	1100 0111
H	1100 1000
I	1100 1001
J	1101 0001

K	1101 0010
L	1101 0011
M	1101 0100
N	1101 0101
O	1101 0110
P	1101 0111
Q	1101 1000
R	1101 1001
S	1110 0010
T	1110 0011
U	1110 0100
V	1110 0101
W	1110 0110
X	1110 0111
Y	1110 1000
Z	1110 1001

In fact, 256 ways are more than enough to code for all the items, with some to spare which can be used for various other signs in future. Nowadays, two standard codes for the 8-bit byte computers have come into practice. One is known as the "Extended Binary Coded Decimal Interchange Code" (EBCDIC, pronounced as "EEB-SEE-DICK"). It is shown in Table 3. The other is the "American Standard Code for Information Interchange" (ASCII, pronounced as "ASKEY"). One thing must have become obvious to you by now. The larger the bit-length or byte, the larger is the capacity of a computer to handle numbers. So, large computers have 16 or 32 bits, or even upto 64 bits.

You must also know yet another term which is commonly used. It is called "Word". It is again composed of bits. It is however the bit-length a computer handles at any one time while performing a task. It could be one byte or more. A computer having a smaller word-length is slower than another having a larger word-length, though the calculating speed of both is the same. For instance, if a computer has a word-length of 8 bits, it has to perform the task of multiplying two numbers, each of 8 bits, in two steps. But if the word-length of the computer is 16 bits, it can perform the same task in one step, thus spending half the time on the task. But this, of course, does not mean that with a large word-length, computer can do a simple task faster. In fact, it will become a nuisance. Suppose you want some money in rupees and paise, a big computer will show you paise in decimals upto even six places, which is meaningless for you. Generally, a

word-length is fixed for a computer. But some computers do have a variable word-length so that they can be used both for small and big tasks without causing any nuisance. Do you have any questions, Neha?

"None. Please proceed."

"These were all the fundamentals of a computer. Now, I proceed on to the real work."

6. MY CIRCUITS AND MEMORIES

I have shown you how all mathematical calculations can be reduced to additions and complementations. Now I will introduce you to an electric circuit which does additions of any electric pulses passed through it. This technique is not very different from building a house using a large number of cards. You arrange the cards in such a manner that they form a house. The electric pulses or electrons are allowed to pass through a circuit built in such a manner that they get added up.

Half Binary Adder

Now, an electric circuit should obey the following four basic laws of addition.

$$0 + 0 = 0$$
$$0 + 1 = 1$$
$$1 + 0 = 1$$
$$1 + 1 = 10 \text{ or } 0 \text{ with } 1 \text{ to carry over to the next column.}$$

Examine the circuit in Fig. 6.1. A and B are two switches, A_1 and B_1,

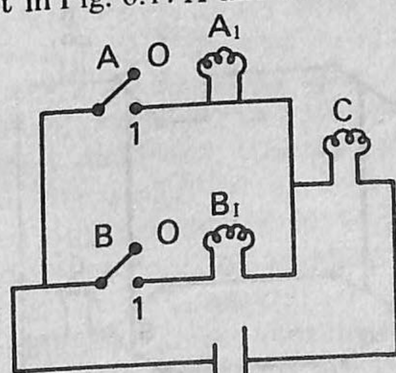


FIG 6.1

their respective indicators, and the indicator bulb C shows the results. When switch A is "off" and switch B is also "off", A_1 and B_1 are not glowing,

and bulb C is also not glowing.

In other words,

$$0 + 0 = 0$$

When switch B is "on", B_1 glows and so also C.

In other words

$$0 + 1 = 1$$

Also,

$$1 + 0 = 1$$

But the circuit shows

$1 + 1 = 1$, when both the switches are "on" and not $1 + 1 = 0$ and 1 carry over.

Therefore, examine the following circuit (Fig. 6.2). Check this circuit

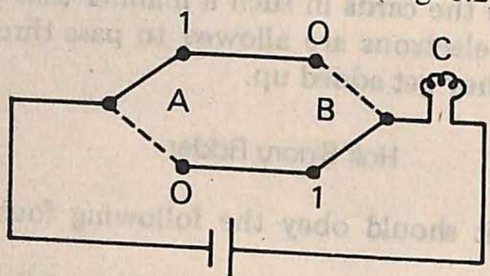


FIG 6.2

for the first three laws. It also obeys the fourth law. In other words, when switches A and B are on 1 and 1, bulb C does not glow.

i.e. $1 + 1 = 0$

But, what about the "Carry over digit 1"? Another circuit has to be added. Examine the modified circuit (Fig. 6.3)

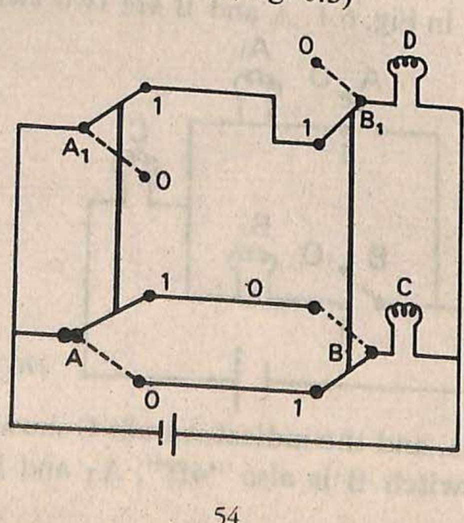


FIG 6.3

The switches A and A_1 move together and so also B and B_1 as the bars between them show.

So, when at A and B, the switches are "on"

$$1 + 1 = 0$$

At A_1 and B_1 also, the switches are "on" and the bulb D glows.

$$1 + 1 = 1$$

In other words, the bulb D gives the "carry over" digit 1. Check that the circuit obeys the rest of the laws. This circuit is known as the "Half Binary Adder". When every step is taken electrically — every switch is opened or closed electrically — you can well imagine that all the additions and mathematical calculations are performed at a lightning speed. Fantastic — is it not? That's us computers!

Logic Circuits

Apart from mathematical calculations, you know that we computers also use logic to take certain decisions, just as you yourself do. Frankly speaking, there is absolutely no difference between you and us computers in this respect, but, again, we do take decisions at a faster speed than you human beings. Oh! I am sorry! I hope you understand what I meant when I used the word "logic". Remember the case of the selection of the books from the money that was left after buying the cycle and wrist watch? Some logical decisions were taken after knowing what you had "programmed" the computer to do. Of course, it is only on the basis of electric pulses that we computers take logical decisions. How do we do so? Here again I will give you a glimpse of our way of working without giving so many details.

It is sure that logical decisions are taken on statements. For instance, you may say "I have hundred rupees in my bank" and after a few seconds, you may say, "There is no money in my bank". Is this not a contradiction? Only one of the two statements could be true. The other is false. By consulting your bank, the truth or falsity of your statements can be checked. Now, instead of the second statement, you may say, "I want to withdraw one hundred rupees from the bank." It is obvious that what you meant was, "I have one hundred rupees in my bank, which I want to withdraw." However, if you had made the second statement as "People are not efficient in my bank", there is obviously no connection between the two statements. Nobody, including us computers, can do anything about them unless it has only to be checked whether the statements are true or false. In short, I wanted to tell you that we computers can take logical decisions regarding two statements if they say something about a common issue — just as you

human beings can. Let these statements be called "a" and "b" and the resulting logical decision or conclusion as "x". As I mentioned earlier, every statement can be true or false. I denote every statement which is false as "0" and every statement which is true as "1". The algebra thus employed is known as "Boolean Algebra".

Suppose there is a statement (a) "It is cold outside." You want to retain it as such

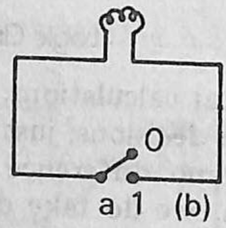
In other words, x = a

If a is false, x is false.
If a is true, x is true.

Elementary — is it not? The above can also be written in the following form which is known as "truth table". [Fig. 6.4 (a)].

a	x = a
0	0
1	1

x (a)



(b)

FIG 6.4 (a-b)

In this case, a circuit as follows is self-explanatory [Fig. 6.4 (b)]. The switch is "a" and the resulting decision is the bulb "x".

However, if you want to negate the statement (a), then you have x = $\overline{a}$. The small bar above "a" shows negation or opposition. In other words, when (a) says "It is cold outside", (x) says "It is not cold outside." In other words,

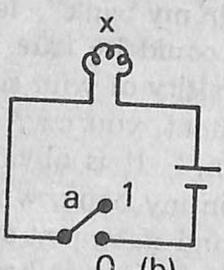
If (a) is true, (x) is false.

If (a) is false, (x) is true.

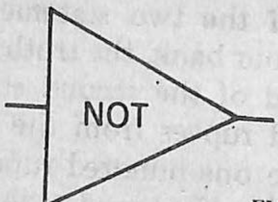
That's fine — is it not? The truth table is given in Fig. 6.5 (a)

a	x = $\overline{a}$
1	0
0	1

(a)



(b)



Symbol

FIG 6.5 (a-b)

The circuit is as shown in Fig. 6.5 (b).

This is called a "NOT gate". It is also used for complementation of a number which is used in subtraction.

Let us consider another case. If there is an additional statement (b) "Snow is falling", then the resulting conçlusion or decision (x) will be: "It is cold outside and snow is falling."

In other words, $x = a \times b$

If (a) is false and (b) is false, (x) is also false.

If (a) is false and (b) is true, (x) is still false.

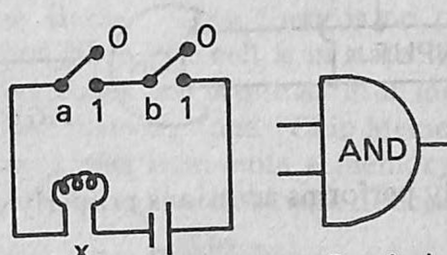
If (a) is true and (b) is false, (x) is still false.

i.e. (x) will be true only if (a) and (b) are true.

In terms of the truth table in Fig. 6.6 (a), the circuit is as in Fig. 6.6 (b) The bulb (x) will glow if and only if both switches (a) and (b)

a	b	x = axb
0	0	0
0	1	0
1	0	0
1	1	1

(a)



(b)

Symbol

FIG 6.6 (a-b)

are "on". This is known as an "AND gate", circuit.

Finally, if (x) is a decision of choice, then (x) will be true when either (a) or (b) or both are true.

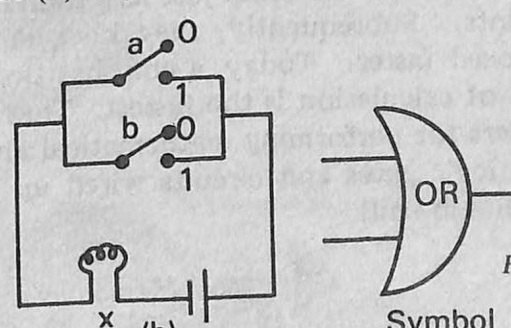
In other words,

$$x = a + b$$

In this case the truth table and the circuit known as "OR gate" are represented by Figs. 6.7 (a) and (b) respectively.

a	b	x = a + b
0	0	0
1	0	1
0	1	1
1	1	1

(a)



(b)

Symbol

FIG 6.7 (a-b)

In the above pargraphs I mentioned a few simple circuits which we computers often use. They are collectively known as "Logic Circuits". They are used in various sequences and combinations to form the complex

circuitry present inside a computer like me. These circuits can be used not only for logical decisions but also for various mathematical calculations. For instance, the aforementioned "Half Binary Adder" can also be a combination of various logic circuits (See Fig. 6.8). You can satisfy yourself

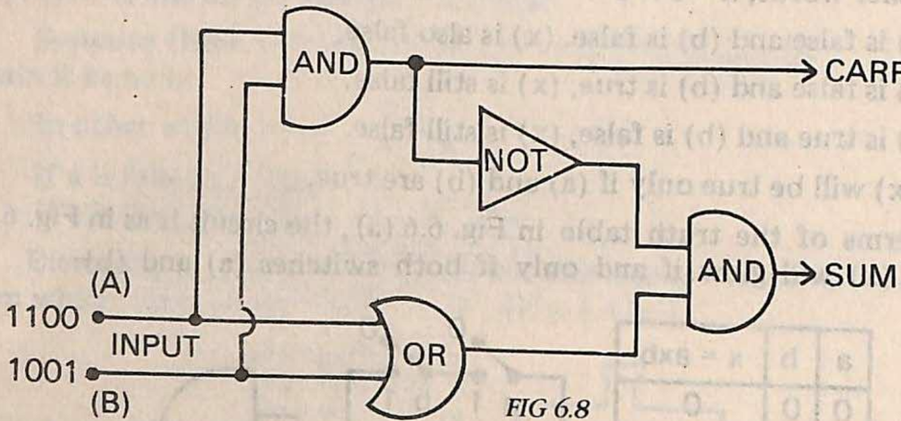


FIG 6.8

whether it really performs additions properly or not.

The Chip

Now, you have seen how various circuits or logic gates perform various mathematical and logical tasks when electric pulses or packets of electrons are passed through them. In fact, electric pulses are literally steered through them, like a train is steered through a number of stations by changing the railway track. In the early days of our history, electromechanical or telephone relays were used as switches; then came the electronic vacuum tubes and transistors, and today it is the all encompassing chip. In those early days, computers were slow because their electro-mechanical switches took more time to open or close just as a train had to wait longer at various signalling points. Subsequently, they became faster as the switches also opened or closed faster. Today, a chip has the fastest switches and therefore its speed of calculation is the fastest. That is why chips are used today in all computers for performing mathematical and logical tasks. It contains all the above logic gates and circuits wired up together on a silicon chip, the size of a thumb-nail!

Main Memory

Have you seen pigeon-holes or rows of letter boxes in any big office? Each pigeon-hole is allotted to a division in the office. Any letter addressed to any person in the division is therefore kept there by the postman. Every day a person from the division collects the letters in his division's pigeon-

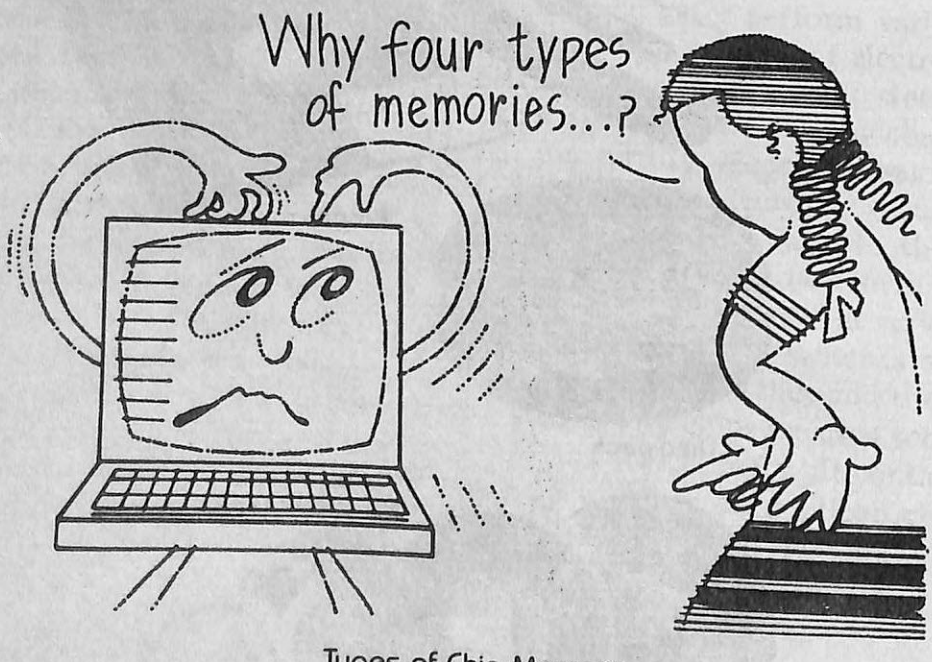
hole and distributes them in his division. In the same way, the main memory of a computer has pigeon-holes — "memory cells" where numbers are stored for later use. When they are needed, they are withdrawn from the main memory. Such a withdrawal of a number from the main memory is known as "retrieval" in computer terminology. Like letters, numbers also enter the memory cells, stay there, and are withdrawn when required. Besides, like letters, every number also carries an address of the memory cell because this is necessary if it has to be retrieved at a future time.

How does a memory cell store a number, an alphabet or a sign? Every memory cell has two states "0" and "1" bits, which, as you know, represent various decimal numbers, alphabets and signs in various combinations. The electric pulses activate these states. When there is no pulse, the cell is in state "0" and when there is a pulse, the cell is in state "1". There are various ways in which these two states are acquired in a memory. Two important ones are "Magnetic Core Memory" and "Chip Memory". In magnetic core memory, a small, round ring represents a memory cell. When there is no pulse, the ring is magnetized in the clockwise direction; and when

FIG 6.9 Various types of memory storage devices.

there is a pulse, it is magnetized in the anti-clockwise direction. The numbers are thus stored and transformed back into no pulse or a pulse when they are required for calculations. The process is similar in case of a chip memory also. The only difference is that instead of rings, in this case, the pulse or no pulse is stored in a type of gate mentioned above. The gate is charged when there is a pulse and is not charged when there is no pulse (see the previous gate when x = a).

Like pigeon holes the memory cells—magnetic rings or gates — are arranged in huge stacks. For obvious reasons, the storage capacity of a magnetic core or chip memory is the number of memory cells it has. It is measured in terms of kilobytes (KB). One kilobyte is equal to 2^{10} or 1024 or approximately 1000 bytes. The measurement of the memory capacity of a chip or magnetic core is carried out in terms of 2 because every memory cell can store either of the two bits, 0 or 1. The storage capacity ranges from a few K bytes for small computers to several thousand K bytes for large ones. For still larger memory storage, megabyte is used. One megabyte (MB) is approximately equal to 1 million bytes. In the days to come, "Magnetic Bubble" memory, which will have ten times more capacity than a chip memory, is likely to be employed.



Types of Chip Memories

Like chips are fast at calculations, they are also fast at storing numbers. In other words, chips have less "access time" as compared to other memory devices such as magnetic core memory. Access time is the time required

to retireve a bit from a memory. The shorter the access time, the quicker the calculation is performed because from time to time bits have to be kept in storage and retrieved as and when required. Besides, a chip memory is also cheaper and occupies less space as compared to the magnetic core memory. These are the reasons why chip memories are widely used in almost all the computers. There are four types of chip memories. . . .

"Stop!" Neha pressed the button and added, "Why are there four types of memories? Is one not enough for a computer?"

"I will explain this using our previous example. If you care to examine the role of memory in the example, you will indeed find several ones. Now, when you received the money from the bank, you kept that fact in your memory. You did not forget it even after you had spent all the money — is it not? You have kept it in a sort of "permanent memory". You could have recalled this amount of money even after several days. Subsequently, you went on buying things and you went on deducting the amount of money from whatever was left in your pocket. In other words, you had also a "temporary memory" to keep count of the money as it was bei ̧ spent. So, in the same manner, a computer also needs a variety of memories for performing different tasks.

Each type of memory is used as per the requirement. The most commonly used is the "Random Access Memory" (RAM). Bits can be stored in the chip only as long as electricity flows through it. Once the electricity stops flowing, all the bits stored in it are also lost. In the "Read Only Memory" (ROM), any bit can be stored in it at the time of the manufacture of the chip. The very term "read only" means the bits stored in the chip can be read or retrieved only, just as words written in a book can only be read. The bits, like words in a book, are not lost when electricity stops flowing through the chip . Such a chip is employed where a particular task has to be performed again and again, like reading a text-book. For instance, such a chip is used to store the program of a washing machine or a video-game.

The "Programmable Read Only Memory" (PROM) is like a note book. Nothing is written in it. But once you write a program in it, it can only be read when you desire. You cannot erase or rub off what is stored in it. Such a chip is used for keeping some information or program permanently for future use. The "Erasable Programmable Read Only Memory" (EPROM) is a modification of the PROM chip in the sense that the bits stored in the chip can be erased using ultraviolet light. The chip can therefore be used again for storing some other bits of information or program. It is like a slate. You can write anything on it, read it when you want, and erase it by simply rubbing or washing off the slate. The slate is then

clean again for writing anything else. Of course, no new information can be stored in an EPROM chip unless the old one has been erased. Here I also wish to say a little about the "Backing Store". Naturally, the access time for these memory units is high because mechanical movements, such as those of a disk drive are required, which are absent in a Main Memory Unit. Consulting these devices is like consulting a dictionary while one is reading. After all, it takes more time to take out the dictionary and find out what is required rather than consulting the "glossary" at the back of the book, i.e., the Main Memory Unit of the computer itself.

How a Computer Works

How a computer works can now be summed up. You have seen that it is nothing but a play of electric pulses, the bits 0 and 1. When you feed data and program into a computer through an Input device, the latter translates them into the code language of electric pulses or bits which are immediately stored in the Main Memory Unit. From the Main Memory Unit, the data and program are transferred in the form of electric pulses to the Arithmetic and Logic Unit, where they are steered through circuits and logic gates. While some mathematical and logical tasks are being performed in the Arithmetic and Logic Unit, some intermediate results in the form of electric pulses are sent to the Main Memory Unit for storage and retrieval. After the Arithmetic and Logic Unit completes the given tasks, the final result is transferred to the Main Memory Unit, which promptly passes it over to the Output device. The Output device translates those electric pulses back into the language which human beings understand. Any questions, Neha?"

"Yes, I have one question. You have mentioned that electric pulses are transferred from one unit to another for performing a particular task. But, I want to know who decides what has to be transferred and where."

"That's a good question. Well, it is the Control Unit. However, the electric pulses themselves carry these instructions as "address" and "operation". The "operation" instruction can be an arithmetic operation, a logical operation, or a transfer operation. The "address" can be of Main Memory Unit, the Arithmetic and Logic Unit, or Input/Output device. Every electric pulse carries these instructions at every stage. For instance. if Rs 20 has to be subtracted from Rs 50 to give the result Rs 30, then the electric pulses of Rs 20 and Rs 50 carry the instructions for the task. The first instruction is that each should be transferred to the Arithmetic and Logic Unit, where the substraction will be performed by the method of complementation and addition. The resulting electric pulses of Rs 30 have both the address and transfer operation for its transfer to the Main Memory

Unit. From the Main Memory Unit, the electric pulses have the address and transfer operation for their transfer to the Output device which shows Rs 30 as the result. In case Rs 30 was to be used in some subsequent task, its electric pulses carry the address and operation. instructions accordingly Do you have ny questions, Neha?

"None. Please proceed."

"Okay, let us go on to the next chapter now."

Chip Making

Sand is melted at a very high temperature and silicon is produced. Silicon is in the form of a long cylinder, one metre long and 10 centimetres in diameter. It is sliced into thin "silicon wafers", each 0.5 millimetre thick, by a diamond. Some photographic techniques are used to draw the circuits on the wafer. It is then chemically treated so that various types of logic gates are produced on it. These gates are connected by thin films of metal to form various circuits. Each such silicon chip is then tested using fine probes. If it is found okay, it is sealed in a plastic or ceramic box. All these processes are conducted in clean, dust-free rooms and at one time several chips are manufactured.

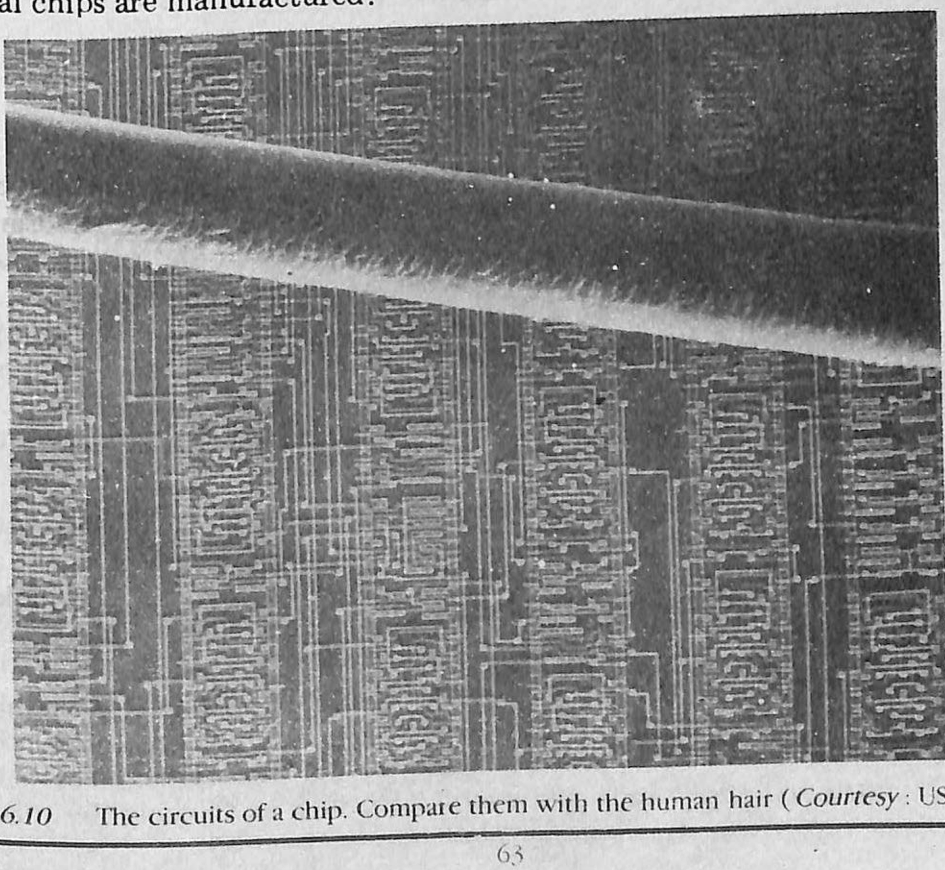


FIG 6.10 The circuits of a chip. Compare them with the human hair (*Courtesy*: USIS)

7. INSTRUCTING ME TO THINK

I am about to reveal to you the most ugly truth regarding myself.

That ugly truth is "I do not think". Then, how do I perform all those wonderful calculations? How do I perform all those tasks which bring me the credit of being a marvellous efficient and accurate machine? Certainly, I am a marvellous, efficient and accurate machine! But that does not in any way imply that I am a wonderful thinker as well. If you think so, I am not to be blamed. So, who does all that brilliant thinking? None but human beings like you, who are known as programmers. Programmers think on my behalf. It is in their brilliance that we computers shine and dazzle.

Programming

If you will recall the third section, I had talked about "program" there. You will recall the example of your father having given you a one thousand rupee cheque allowing you to buy a cycle, a wrist watch and books. Let us examine that very example again so that you will have a glimpse of what is called programming. You will recall that I had said that you always make a program whatever the task is given to you to perform. You however do it unconsciously so that it is only occasionally that you realise you have made a program — and not that you do so every time you have to perform a task.

Now, if you consciously make a program to perform the above task of buying things with a thousand rupee cheque, you may write it down as follows. The arrows show the direction of your steps(Fig. 7.1). It looks elementary — is it not? But if you examine each of the above steps, you will find that each one can further be broken down into still smaller steps. For instance, take the first step of withdrawing money from the bank. It consists of ten smaller steps as shown in Fig. 7.2. If you have no idea of the location of the bank, you will also have to get directions. You will have to be instructed about each and every step, such as crossing the road,

take the right turn, etc, if you are a stranger to the locality. And if you do not know how to walk. . . This is becoming ridiculous! You may exclaim. It does sound so, but it is not. Even when you walk, although your actions have become automatic due to habit, you make a program unconsciously. For instance, think of the moment when you have to cross a hedge or a narrow crowded street. You take every step carefully giving attention to things that come in your path. It is then as though you had set up a program to walk!

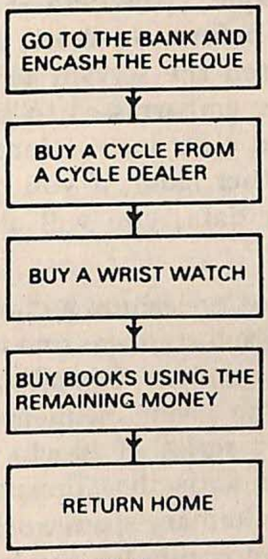


FIG 7.1

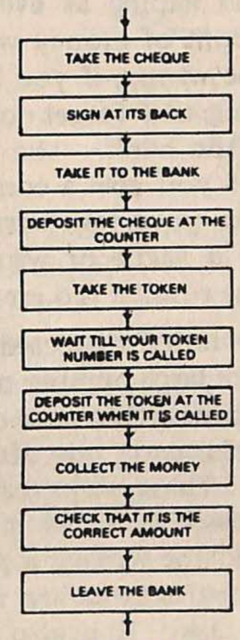
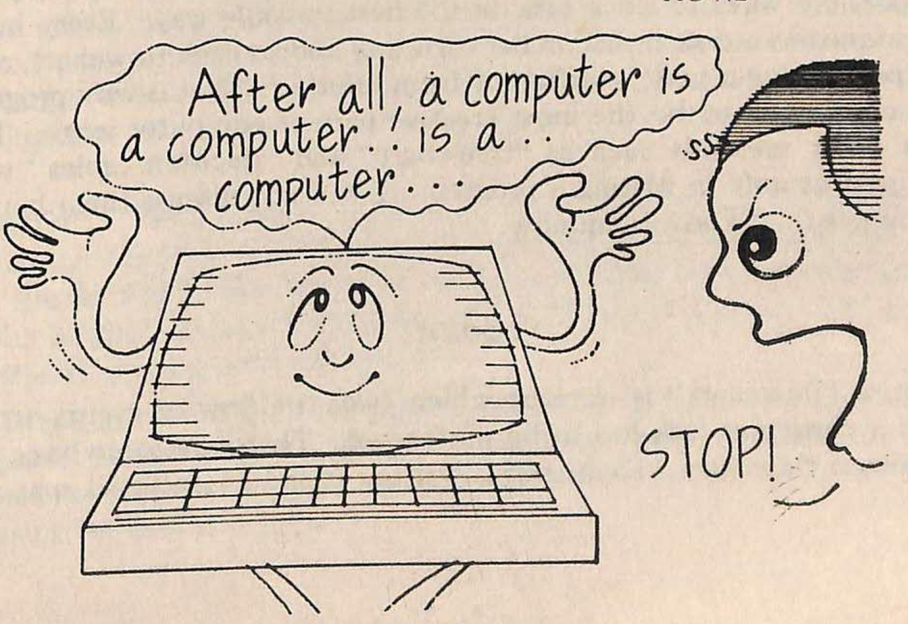


FIG 7.2



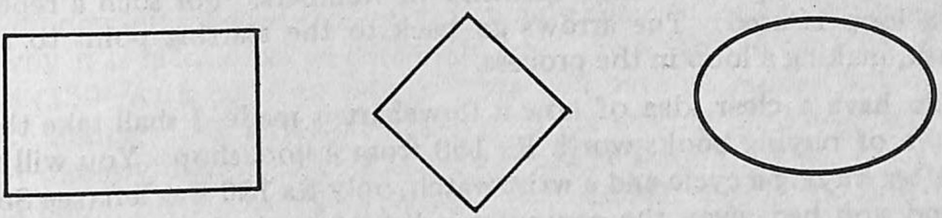
Now, instead of your going to the bank yourself if you hire a servant who is new to your locality and has no idea about a bank, what will you do? Obviously, you have to give him all sorts of instructions about the path to be taken, the dealings in the bank, and the return path, except, of course, how to walk – in a step by step manner. And if you give him even one wrong or confusing instruction or data, you will not get the money from the bank. The servant may take a wrong turn somewhere and will enter a wrong place instead of a bank. Or, he may not deposit the cheque at the counter and will stand gaping at every one, waiting for the token to be called! Even the amount of money written on the cheque – the data – may itself turn out to be wrong, if you had not checked before. In short, you should assume nothing and forget nothing when you tell the servant to withdraw money from the bank. The same, I am rather embarrassed to say, is true about me! If you give a computer correct and clear instructions and data it will perform your task correctly. On the other hand, if you miss something or give a vague or wrong instruction or data, you will also receive wrong or vague results. To err is human: GIGO!

You saw how I dissected the simple task of encashing a cheque from the bank into a large number of simpler steps. Each step was one tiny job to be done at a time. One task consists of a large number of small steps which are to be performed one after another, in the given sequence, till the task is over. These steps can be written in a series of blocks as shown (Fig. 7.2). However, a still more effective method is the "flowchart". It is basically an aid for writing a program – the preliminary spadework which is done before instructions are written, telling the computer the logical way of doing the task. It is also a good mental exercise because you have to try all possible ways to do a task in the best possible way. Every human being approaches a task in his on her own way and so each flowchart, or the way of performing a task, is different from another. That is why progrramming is considered to be the most creative part of computer work. There are also other methods such as "tree-chart" and "decision tables" which can be used as aids in writing a program. I will not discuss them here because you need not know them now.

Flowchart

Basically, a "flowchart" is a chart which gives the flow of events or steps in which a particular task has to be performed. There are some basic rules for drawing a flowchart. Each step is written inside an enclosed space of a

particular shape, namely, rectangle, square, diamond, circle, ellipse, etc. The shape indicates the type of step to be undertaken. In other words, these shapes are like symbols. A few such symbols of flowchart are given in Fig. 7.3, which needs no explanation. Lines with arrows connect these symbols showing the direction of flow of events or steps.



PERFORM THIS STEP | TAKE A DECISION | STOP OR START THE TASK

FIG 7.3

If at any stage during the performance of a task, a decision has to be taken the step should be carefully studied. The decision to be taken has to be rephrased into a question whose answer can only be a "Yes" or "No". For instance, the answer to a question such as "Is there money in your bank?" could only be a "Yes" or "No" after consulting your bank. The question should not be vague such as "How much money is there in your bank?" because then the answer will also be vague. Naturally, when you want a task to be performed, you know it will not be performed if there is vagueness at any step. Moreover, if the task given to me has been performed, you need to inform the Control Unit of the computer about it. You have to tell the unit in very clear, blunt terms to stop, as soon as the task is done. Otherwise, the Control Unit will continue to perform the task as long as the universe exists, or till the power supply to the computer is not exhausted, or till the parts of the computer do not wear away due to overwork! After all, a computer is a computer, is a computer, is a computer, is a computer, is a computer, is a computer, is a computer, is a computer, is a computer, is a . . . . "

"STOP!" Neha pressed the button with impatience. The green words immediately stopped. Has the computer gone haywire? she wondered. What should she do now? She was about to leave her seat when something struck her. She laughed to herself and pressed the "START" button. The greenish words started moving across the screen.

"That's good!" That's how you should tell a computer to stop once it has performed your task. To cut a long story short, you have to draw a flowchart to perform a task in such a way that it does what it is expected to do using the available data.

One important aspect of flowchart is the "loop". It is meant for repeating a task. For instance, nobody wastes his time drawing a flowchart for simply adding two numbers. He does so only when it is a question of addition of scores of hundreds or millions of numbers. In other words, a flowchart is prepared when it is the addition of two numbers to be performed repeatedly for a large quantity of numbers. For such a repetitive task, a loop is used. The arrows go back to the starting point to repeat the task, making a loop in the process.

To have a clear idea of how a flowchart is made, I shall take the old example of buying books worth Rs 150 from a bookshop. You will recall that after buying a cycle and a wrist watch, only Rs 150 was left (see Section III) and you had given the computer a list of books in the order of your preference. So, you start with Rs 150. You pick up the first book, examine its price (A) and if it is less than Rs 150 you buy the book. An you go on repeating this procedure each time in accordance with the money left till you have no money left to buy a book. This is a simple logical procedure. The flowchart for performing these tasks is shown in Fig. 7.4. Start from the top of the page, as is the general practice.

In Fig. 7.4 you can notice two decision boxes and two loops. The

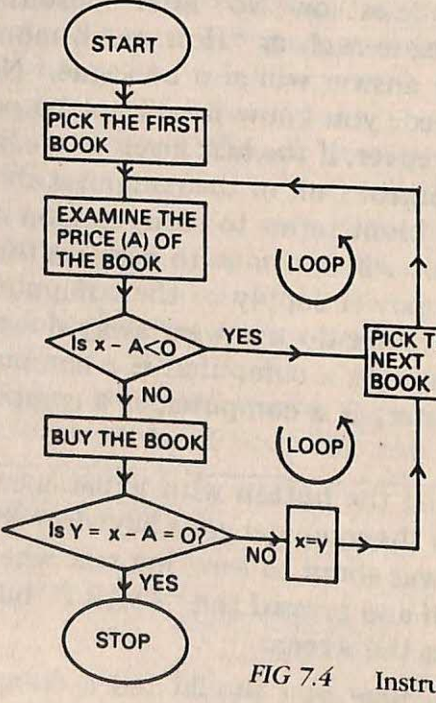


FIG 7.4 Instructing me to think, x = Rs. 150

first decision is whether the price of the book falls within the available money or not. If it does not, the next book is picked and its price examined. If it is within the available money it is bought. After buying the book, you examine how much money is left, if it is Rs 150—A, where A is the price of the book picked. Naturally, when Rs (150—A) is not zero, there is still money left. So, at this stage, you have again to take a decision, and that is why it is mentioned in a decision box. You thus go on buying books till Rs (150—A) is equal to zero — when you have no money left in your pocket. Simple — in it not? However, while writing the flowchart, Rs 150 is not directly used because it is not a constant amount. After every purchase of a book, the amount gets accordingly reduced. So, in the flowchart, x = Rs 150 is assumed to start with, where x is the amount of money available at any moment to buy books. You can see that as books are being purchased one after another, x gets reduced, but it is the amount within which books have to be bought. This is the reason why after every purchase x is made equal to y, where y is the remaining amount after buying a book. Until y is not zero, the process of buying books continues. Moreover, after every purchase of y = x, if y is not zero, it is the money then available for buying books. You must have noticed by now how the questions have been re-phrased in the decision boxes as to give a "Yes" or "No" answer. Also, in the beginning, a "START" instruction is given and a "STOP" at the end.

Making the above flowchart was simple but it is not so when a difficult and complex task has to be performed. In fact, making a flowchart needs a totally novel way of looking at a task or problem. To gain proficiency in doing so there is nothing to substitute practice. However, a flowchart is the first step in the process of programming. One a flowchart is made for a task or problem, it is written in a series of minute steps or instructions, just as mathematical steps are written — one below the other. Such a sequence of minute steps is called "Algorithm" named after an Arabian mathematician, Mohammed ibn Musa Al-Khwarizmi, who first wrote mathematical steps in this manner. But the algorithm for a task or problem has to be written in a language that the computer understands. That language is naturally known as the "Computer Language". I will discuss the language in the next section.

Before I close this section, one thing I wish to bring to your notice. Any task or problem which you are not able to break down into a series of steps or instructions cannot be handled by us computers. In other words, we computers, as your servants, can only go by your program. If you yourself are not able to write a program for a task or problem — by "you"

I don't mean you personally but you as a human being — we computers will also not be able to perform that task or solve that problem. You may naturally be curious to know what are those tasks or problems. Well, they are abstract. Do you have any questions, Neha?"

"No questions. Please proceed", Neha typed in, though the last few sentences puzzled her.

8. MY LANGUAGE AND PROGRAMS

For any kind of communication among human beings, a commonly understood language is a must. Any human language, whether it is Hindi, English, German or Swahili, has a huge vocabulary and can therefore express all shades of feelings — from concrete to abstract ones. This is owing to the gradual development or evolution of these languages over the last several centuries. However, the communication between you and me has begun only in recent times. Computer language, which you as well as I can understand, has very limited vocabulary. Therefore, only limited instructions, leave alone feelings, can be communicated between us. In fact, for obvious reasons, the computer language is brief and to the point. It has no scope for confusion or distortion — the cause for so much misunderstanding among human beings!

I have mentioned in Section V that the computer language is in the form of electric pulses—binary digits or bits, 0 and 1. It contains both the operation and address of the instruction to be executed. A computer language in such a crude form is called "Machine Language" because it is the language we computers understand without the need for any interpreter or translator. The binary digits employed as a language is called "Machine Code".

In those early days when the electronic digital computer was a new invention, the machine code was used for giving instructions to the computer. It is still used today when any task has to be performed at an exceptionally high speed. Why a task is performed faster using a machine language is obvious. A computer does not have to spend time on translating a language because it is available in its own language of functioning. However, frankly speaking, this machine language is looked down upon these days because it is cumbersome and tedious to handle. You can well imagine that yourself if you have to write a sentence in terms of only 0 and 1. Nowadays, it is therefore known as a "Low Level Language".

There is another low level language which is also sometimes used.

It is called "Assembly Language". In this types of language some memory aids — "Mnemonics" — are used instead of binary digits. Instead of using the words such as multiply, divide, etc, their abbreviation or mnemonics such as 'MLT', DIV, etc, are used in the language. A program called "Assembler" translates these mnemonics into binary digits or bits. These bits are, of course, part of the machine language which the computer understands directly.

Now, suppose you yourself have to write an instruction or step. Either of the low level language will be extremely difficult for you to write. For this purpose "High Level Languages" have been developed, thanks to the wide-spread use of computers in all walks of life. High level languages are a subset of English. It is therefore easy for you to write any instruction or step — in short, any program — in one of these languages. A machine called "Compiler" translates the high level language into the machine language and transfers the instructions or steps in binary digits to the Memory Unit for further action.

There are today several types of high level languages, each developed to perform a particular type of task. In other words, each is a specialised language which suits only a particular type of task. For instance, if you want to solve a scientific research problem involving a lot of mathematical calcu-lations, formulas and equations, FORTRAN (FORmula TRANslation) and its cousin language ALGOL (ALGOrithmic Language) are used. If you want to solve a business problem involving a lot data and files COBOL (Common Business Oriented Language) is employed. But if you want to learn a langu-age quickly BASIC (Beginner's All-purpose Symbolic Instruction Code) is to be learnt. It resembles FORTRAN in many ways, yet it can be used to perform any business task. It is simple, powerful and can be used for any type of task. In recent times, it has become very popular due to the wide-spread use of microcomputers (see Section IX). Then there is also PASCAL, named after the French pioneer, to teach programming to students. PL—1 (Programming Language—1) has also been developed, which, though not populai, can be used in a wide variety of applications both in business and scientific research. Besides there are some languages meant exclusively for a specific application. For instance, ADA, named after another computer pioneer Ada, the Countess of Lovelace, is used only in defence applications. In recent times, a new class of languages, know as "Declarative languages", has also been developed. Called LISP, PROLOG and HOPE, these languages, though they can be used on the present computers, are only good at performing some specific tasks. Also, language such as dBASE II and dBASE III have appeared on the scene. These languages, if one can call them so, were basically developed to communicate with

a database (see Section XI), which is often present in all organisations. However, the ease with which you can communicate with a database for various purposes has made these languages very popular. You need not know anything about computers and programming to make use of these languages!

It should however be borne in mind that every high level language has its own rules, its own way of presentation and its own vocabulary. You cannot therefore mix any two languages to perform your task. Fig. 8.1 (below) shows how one language differs from another in stating a particular problem.

BASIC

```
00010  PRINT 'THIS PROGRAM FINDS THE SUM OF FIRST N '
00020  PRINT 'NATURAL NUMBERS WHERE N IS THE NUMBER '
00030  PRINT 'SELECTED BY YOU '
00040  PRINT 'ENTER THE VALUE FOR N ';
00045  INPUT  N
00050  FOR I = 1 TO N
00060  S = S + I
00070  NEXT I
00080  PRINT 'SUM OF FIRST ';N;' NATURAL NUMBERS IS';S
00090  END
```

FORTRAN

```
      PRINT *,'THIS FINDS THE SUM OF FIRST N '
      PRINT *,'NATURAL  NUMBERS WHERE N IS THE NUMBER '
      PRINT *,'SELECTED BY YOU '
      PRINT *,'ENTER THE VALUE FOR N ?'
      READ *,N
      J = 0
      DO 10 I = 1,N
      J = J+I
   10 CONTINUE
      PRINT *,'SUM OF FIRST ',N,' NATURAL NUMBERS IS ',J
      STOP
      END
```

COBOL

```
       IDENTIFICATION DIVISION .
       PROGRAM-ID . COBOLPROG .
       ENVIRONMENT DIVISION .
       CONFIGURATION SECTION
       SOURCE-COMPUTER . UNIVAC-1100-82 .
       OBJECT-COMPUTER . UNIVAC-1100-82 .
```

```
     INPUT-OUTPUT SECTION .
     DATA DIVISION .
     WORKING-STORAGE SECTION .
     77  I              PIC 9(5) .
     77  N              PIC 9(5) .
     77  TOTAL          PIC 9(7) VALUE ZEROS .
     PROCEDURE DIVISION .
START-PARA.
     DISPLAY 'THIS PROGRAM FINDS THE SUM OF FIRST N '
     DISPLAY 'NATURAL NUMBERS WHERE N IS THE NUMBER '
     DISPLAY 'SELECTED BY YOU '
     DISPLAY 'ENTER THE VALUE FOR N' .
     ACCEPT N
     PERFORM SUM-PARA VARYING I FROM 1 BY 1
             UNTIL I IS GREATER THAN N .
     DISPLAY 'SUM OF FIRST ', N,'NATURAL NUMBERS IS'
     ,TOTAL .
     STOP RUN .

SUM-PARA .
     ADD I TO TOTAL .
```

FIG 8.1 Program for finding the sum of first N numbers in three computer languages, namely *Basic, Fortran*, and *Cobol*. You can easily see some distinct differences. For instance, in the *Cobol* program, all the basic details about the computer have to be mentioned in the beginning. The step numbers are also mentioned in different manners in *Basic* and *Fortran*, whereas in *Cobol* no such thing is mentioned.

Writing a Program

Writing a program in a computer language is not an easy task. It needs much familiarity with the language which only constant practice and hard work will help you to attain. A teaching course on a language will make you familiar with its rules, grammer and vocabulary, etc, but nothing more than that. It is only while re-phrasing a flow chart in a computer language that you will be able to practice your skill. In other words, learning a computer language is like learning any foreign or regional language. One can become expert in a language only by speaking, reading and writing in it, day in and day out.

However, when a task or problem is given to you, you have first of all to decide the type of language you should use. Naturally, your choice of

the language also depends upon the computer at your disposal. Once the language is decided. you have to re-phrase the entire flow chart of the program in the selected language. Here the mastery of the language will come to your aid. Each statement in the language represents each step of the flowchart. You have to check every statement for the possibility of any ambiguity or fault. Many a time, you have to re-phrase your statements, again and again, so that the instructions become clear and precise. You have to be very careful about the logic and sequence of the statements. If anything goes wrong here, no computer can help you. It will simply follow your instructions without giving it a thought. If at some stage of a program, you denote a quantity as "NUT", then you have to use "NUT" for that quantity throughout the program. You must also see to it that you have written the "START" and "STOP" instructions at appropriate

```
00010 PRINT 'THIS PROGRAM SELECTS THE BOOKS WHICH '
00020 PRINT 'CAN BE PURCHASED WITHIN THE AVAILABLE
00025 RS 150'
00030 DIM B$(10),A(10),S(10)
00040 LET X = 150.0
00050 LET J = 0
00060 FOR I = 1 TO 10
00070 READ B$(I),A(I)
00080 IF A(I) > X THEN 120
00090 LET J = J + 1
00100 LET S(J) = I
00110 X = X - A(I)
00120 NEXT I
00130 PRINT 'THE FOLLOWING BOOKS CAN BE PURCHASED
00140 PRINT 'WITHIN THE AVAILABLE RS 150
00150 PRINT 'NAME ',' PRICE '
00160 FOR I = 1 TO J
00170 PRINT I;B$(S(I)),A(S(I))
00180 NEXT I
00190 PRINT 'BALANCE AMOUNT REMAINING > ';X
00200 DATA 'NETWORK REVOLUTION',100.0
00210 DATA 'THE WORLDLY PHILOSOPHERS',160.0
00220 DATA 'THE ANDROMEDA STRAIN',150.0
00230 DATA 'GREAT EXPECTATIONS',30.0
00240 DATA 'COMPUTER PIONEERS',10.0
00250 DATA 'DELHI GUIDE MAP',5.0
00260 DATA 'SCIENTISTS OF INDIA',20.0
00270 DATA 'GREAT DISCOVERIES',25.0
00280 DATA 'A GUIDE TO BIRD-WATCHING',120.0
00290 DATA 'A BOOK OF NONSENSE',200.0
00300 END
```

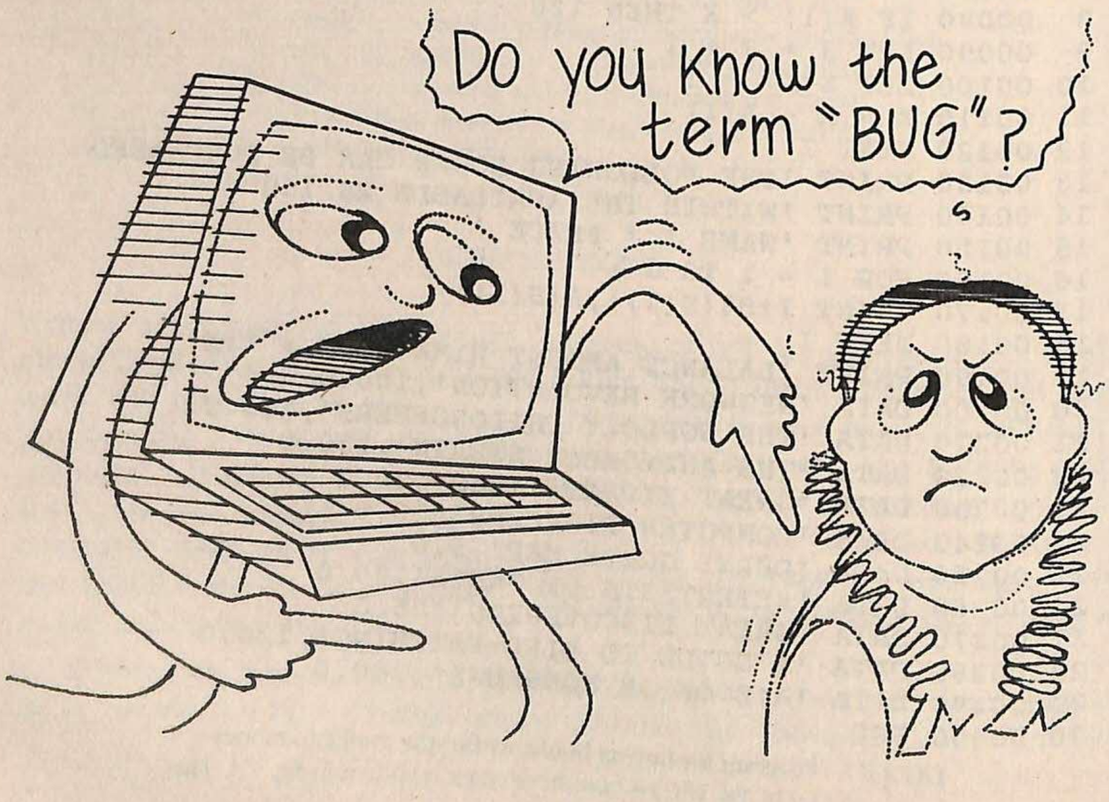
FIG 8.2 Program for buying books within the available money (x = Rs. 150) whose flow chart is shown in fig. 7.4. This programme is in *Basic*.

places. If you do not do so, God alone can help you! The program of the above flowchart for buying books (see Section VII, Fig. 7.4 has been rephrased into a computer language to give you an idea of how program finally look before they are fed into a computer (See Fig. 8.2).

There are, however, some programs known as "Diagnostic programs" in a computer, which are able to point out any errors that you may commit in the use of a language. Such errors are commonly known as "bugs". A bug literally means a bug or insect. Do you know how this term came to be used in computer vocabulary, Neha?"

"No. Sorry. I don't know," Neha typed in, eagerly, "Please tell me how".

"I will tell you how. Those were the early days of computers, in the forties. One of our ancestors, the giant Mark I installed at Harvard University, U.S.A., refused to function, although great effort was made to diagnose the problem. Eventually, the computer-machine was opened up and examined. A moth was found to have got trapped in a relay. So, in the daily record on the functioning of Mark I was made this entry "the Mark I was debugged today". Ever since then, any problem that occurs in a program is called a "bug". The removal of the mistake is, of course, called



"debugging". How do you find this story, Neha?"

"Interesting. Please proceed", Neha typed in.

"So I shall proceed further. A diagnostic program indicates bugs with asterisk marks(*) as it examines your program. For instance, if by mistake you write MUT for MLT (Mulitiply) the program will indicate the error as MUT*. However, if in one of your statements you write (A + B) instead of (AxB), which is what you want to find out, no dream will ever come to the computer and it won't tell you have mentioned a plus sign instead of a multiplication sign. The computer will go on summing up a A and B for different values of A and B, whereas you want their multiplication! Moreover, no diagnostic program will be able to tell you this mistake. It is only when results appear that you begin to think that some mistake has been made, provided you have some idea of the results you expect.

Suppose at some stage in your program you have to find out the square root of certain numbers for use in the next instruction or step. To find out the square root of a number there is a standard formula — a fixed number of mathematical operations are to be conducted, whether the number is small or big. In such a case, you need not write all the operations to derive the square root. You have simply to call a program lying in the Memory Unit of the computer. Such a program is called "Sub-routine". The sub-routine program of the square root of a number makes the necessary operations on every number and stores the results in the Memory Unit for use in the next step. Whether a sub-routine program of a square root is available in the Memory Unit of a computer or not depends upon the type of language being employed for the task. In FORTRAN language, the above sub-routine is available. This is owing to the simple reason that FORTRAN is used in scientifc research in which finding the square root of a number is frequently required. Naturally, the basic purpose of a sub-routine program is not to waste your time on something which is routine.

Then there are also what are known as "Utility Programs" stored in computers. Such programs can be used again and again with slight modifications for sorting, editing, graph-plotting, updating and reporting tasks. For instance, a program for sorting could be employed for any kind of sorting to be done in an office — from sorting late-comers to sorting data for analysing a problem. Similarly, a program for editing could be used in a newspaper office, or by a manager or person who dictates letters, or a writer, etc. Some programs can also plot a given data or the result arrived at directly into graphical form. In fact, any data can be converted into any type of chart such as pie or bar charts for use in any study. Just at the press of a button! There is also available what is known as a "Monitoring program", which is also called "supervisory control or executive

or operating system program". Its purpose is to regulate the operation of computer, make a schedule of tasks to be performed, assign different tasks to different units, and keep an account of how the computer time has been utilised.

Software Packages

A large number of readymade programs called "Software packages" for performing some routine tasks are also available. You know that software packages are available for tasks routinely conducted in every office such as making salaries of its staff. In other words, you need not waste your precious time and energy on a routine task. You have simply to modify a software package to suit the needs of an office or factory. You can therefore concentrate your energies on the tasks which are specific to your job.

Some software packages for teaching various subjects in a school or college are already available in the market. You have to simply buy the package and you can learn a variety of subjects through your computer. The packages are available like books but function like teachers when fed into a computer.

A large number of companies which sell software packages have begun to appear all over the country. You have simply to tell them your requirement — and they will provide you with the necessary software.

"Do you have any questions, Neha?"

"No, please proceed," typed in Neha.

9. MY FAMILY

"Have you ever seen a huge dinosaur, Neha?"

"Yes, I have. Not a live one, of course. I have seen its model and pictures," typed in Neha, a bit puzzled.

"Dinosaurs are today an extinct group of reptiles. But do not forget that at one time, about 160-65 milion years ago, they were spread, like human beings, all over the earth. Man had then not emerged on the scene. However, in course of time, the climate of earth underwent a major change which dinosaurs could not tolerate and all of them died suddenly. Afterwards a group of smaler animals called "mammals" arrived about 65 million years ago and have since come to stay. Mammals include brainier animals such as elephants, lions, monkeys, etc. From the mammals emerged the man, about three million years ago. It is the most delicate and yet brainiest animal to emerge on the face of earth. And I need not add that he has dominated the scene ever since, thanks to his most versatile, all purpose brain.

FIG 9.1 **Univac, the world's first commercial data-procession computer**

"STOP!" Neha pressed the button because she could not stand the story of evolution of life any more. She then typed in with annoyance, "What are you upto? Is this a section on the evolution of life and the emergence of human beings on earth?"

"No, Neha. No. Have patience. I was about to come to the topic I want to discuss with you. Should I proceed further?"

"Yes, please proceed." Neha typed in, still wondering whether there had been mix up of sections. Some sections on the evolution of life had got mixed up with the sections on computers, she thought. But she was mistaken.

"I have mentioned the evolution of different types of life because something similar happened in our case. When the ENIAC and its cousins the UNIVAC series, the first fully operational electronic digital computers, were built, they were bulky, dull-witted and slow cumbersome to handle, and used to go out of order every other day. Their basic component, the vacuum tube, was the main culprit. Besides, these computers were highly expensive too (see Table I).

Table I. shows how the price of computers has fallen over the years.

Year	Price of the computer for 100,000 multiplications
1952	Rs 15.12
1958	Rs 3.12
1964	Rs 1.56
1970	Rs 0.78
1980	Rs 0.0016

Note : On an average, the price of computers has fallen by 20 per cent every year.

This was about 25 to 35 years ago — to be precise around 1951-1959 (see Section II). These giants are today known as the "First Generation" computers because they were the first generation of machines used on a large scale. Apart from the UNIVAC series, which was employed for business purposes, the IBM company also manufactured the first business-oriented calculating machine, IBM 701, on a large scale.

The "Second Generation" computers arrived on the scene about 20-25 years ago. They were like the mammals — take elephants, for instance — smaller in size, faster in calculations, more reliable, generated very little heat, and consumed less electricity. They were comparatively less expensive too. Instead of vacuum tubes, transistors were their main components. Moreover, these computers had been designed specifically to meet the

needs of businessmen and scientists.

The "Third Generation" computers arrived on the scene about 20 years ago. It was like the emergence of human beings. The "Third Generation" computers are smaller, faster, more reliable and accurate than those of the previous two generations. Moreover, they can perform several types of tasks, are easy to handle and are quite cheap. This is owing to the development of "Integrated Circuit" (IC) technology (see Section II) especially the Medium Scale Integration technology. Using this technology, about 20 to 100 electric components can be accommodated on a silicon chip.

Hardly, a few years ago, the "Fourth Generation" computers arrived. In these computers, a single silicon chip has all the essential units of a computer, namely, the Control Unit, Arithmetic and Logic Unit and Main Memory Unit, thanks to the Very Large Scale Integration technology. It has now become possible to accommodate more than 5,000 electrical components on a single chip. The chip which contains all the three essential units of a computer is called a "microprocessor". As a result of small size and low cost, small computers called "personal or home computers", which are within the reach of the common man, have been manufactured. Moreover, several other types of more powerful computers such as "supercomputers" are also available in the market. In short, computers have today become an all purpose tool like the brain of a human being like you.

The "Fifth Generation" computers are still on the laboratory benches. They are the "super-conducting" computers, whose chips will be super-cooled to make them work faster and more efficiently than the present ones. What about the "Sixth Generation" computers? Time will only reveal them because you must have realised by now that these generations differ from each other in technology. In fact, each generation represents a shift in technology — from vacuum tubes to transistors, to chips, and so on. So the next generation of computers will arrive as soon as there will appear another technological breakthrough.

Whatever the shift in technology may be, I must bring to your attention one simple issue, lest I be blamed later. Nowadays, computer scientists no more use the term "generation" to denote the shift in technology. In fact, some use the term in a totally different sense. For instance, some computer scientists do not consider that super-conducting computers would be the next generation of computers. Instead, they consider machines which would exhibit intelligence to be the next generation of computers. The machines would be intelligent in the sense they would be able to think on their own and take decisions. So, whenever you use the term "generation" the next time while talking to another person be sure that he or

she knows what you are referring to. Do not use the term in a loose manner.

Types of Computers

Man is a marvellous inventor. For instance, he has made a large number of inventions to increase his mobility. From the earliest days to the present, he has invented bullock-cart, tonga, cycle, motor cycle, motor car, ship, railway, aeroplane and finally rocket. In other words, he has been increasing his speed of mobility, just as he has been trying to increase the speed of calculation by computers. However, the change in the speed of computers within such a short period of about 40 years is incredible, if you consider the slow change in the speed of mobility that has come about in the last several centuries. Moreover, the difference in the speed of calculation of a computer used for washing clothes to that of a supercomputer used for predicting weather is also fantastic. No invention of the human being can match such a large variation in speed. In other words, the difference in speed between a bullock cart and a rocket pales into insignificance in comparison with the difference in speed of calculations between the slowest and the fastest computers!

Nevertheless, just as all kinds of transport from a bullock cart to a rocket are available for moving from one place to another, all kinds of computers are also available. You employ a particular means of transport depending on how fast you want to travel and how many people are accompanying you. For instance, a motor car cannot take you to Egypt if you want to reach there within a few hours. Or, a car cannot take you to another city, if more than ten people are accompanying you, you have to go by bus or train or aeroplane. In the same manner, you employ a computer depending on how fast you want your task to be performed and how large your task is. You will not use a slow and low capacity computer, which is used for controlling a washing machine, for forecasting weather which has to be conducted very fast using a large amount of data. Simple logic — is it not?

There are mainly three types of computers, namely, the Mainframe, Mini-computer and Micro-computer. Owing to the widespread use of computer in some commercial activities, a few computers have been especially built to perform some specific tasks. For instance, there are small business computers, word-processors, personal or home computers, supercomputers, etc, each built for a specific kind of market. Let me take all these computers one by one and describe to you their advantages and disadvantages, their uses and potential. But one thing has to be borne in mind that the difference between them is vague. It is not necessarily based on their speed of calculation or their capacity to store data. Each type of computer more or less

represents a particular stage in the development of computers. Nothing more. This point will become evident from the following discussion.

Mainframe computer: This computer is a dinosaur having the brain of a human being. It is basically a technologically advanced version of those giant sized computers of the fifties. Obviously, it is employed when there is a large program to be performed at a fast pace and a large amount of data is

FIG 9.2 The computer room of an airlines office. The computer accommodate 60,000 passengers on 1,500 daily flights in more than 100 cities. It also eliminates paperwork in making reservations and writing flight tickets.
(*Courtesy*: USIS)

involved. You can see such a giant computer only in a big industry or office or computer centre. It is kept inside an air-conditioned hall because its various components are highly sensitive to dust and temperature changes. Input and Output devices, Arithmetic and Logic Units, Memory Unit, Backing Store (see Section IV), etc, of the computer are housed in separate cabinets : Cables running underneath the floor connect all these components. It is naturally an expensive computer costing several tens of lakhs, or even upto a crore or so and is also highly expensive to maintain. Any breakdown or power shortage means a big loss to its owner. It is therefore run round the clock and needs a well-trained staff. Its large storage capacity can easily handle any requirements.

Mini-computer. If the mainframe computer is a dinosaur with the brain of a human being, a mini-computer is an elephant with the brain of a human being. Moreover, unlike a dinosaur which is sensitive to temperature changes and dust it is a robust elephant which does not require an air-conditioned room. It came into being when transistors replaced vacuum tubes. That is why it is smaller in size than a mainframe computer. All of its components can be housed in a body of the size of an almirah or even smaller. It is often used for a specific purpose only. For instance, it is used in a factory to keep an eye either on the quality of goods being manufactured or on a process in progress. Sometimes, it is also used as an assistant to the mainframe computer. The biggest mini-computer is however as good as the smallest mainframe computer both in efficiency and storage capacity and hence no definite distinction is possible between these two types of computers. Ordinarily, the price range of a mini-computer is from five lakhs to tens of lakhs.

Micro-computer: This is the human being itself. A microprocessor is its brain. It is therefore very small in size, compact and handy. It can easily handle a task which does not require a very high speed of calculation and a large memory capacity. Its price range is from Rs 30,000 upto a lakh or so. It has therefore found place in every walk of life and has won the heart of millions.

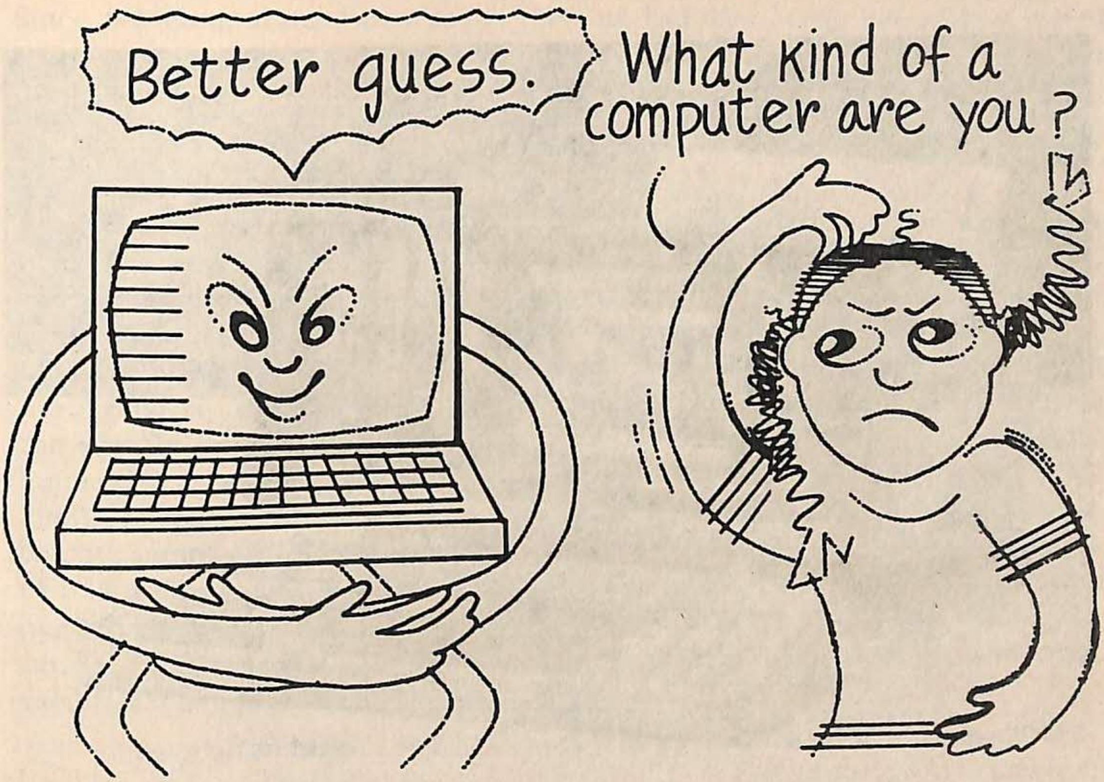
A microcomputer can nevertheless be used for bigger tasks. Additional devices for storage of more data and programs can be added to it for such tasks. Some recent technological developments even enable a microcomputer to acquire speed in calculations and memory storage capacities matching those of a medium-sized mainframe computer....

"STOP!" Neha pressed the button. Then she asked, "What about you? What kind of a computer are you?"

"Better guess, Neha."

"From the above descriptions, I can say that you are a mainframe computer."

"You're right on the dot! Congratulations! I am a mainframe computer. You are simply handling one of my terminals. More about terminals and other details about my working will be discussed in the next two



sections. Should I proceed further, Neha?"

"Yes, please proceed Mr Main-frame computer."

"I will now go on to other special types of computers . . . . ."

Special types of Computers

A "business computer" can be a very small main-frame or mini or large micro-computer. It is basically used for processing data (see Section XI) required in various commercial applications, such as preparing salaries of staff, analysing data to extract an information, etc. A "personal or home computer", a type of micro-computer, is the craze of the day. Hardly the size and weight of a loaded school bag, it can be used for any kind of personal or home work which does not require high speed or large memory storage. Besides being easy to handle, it can also be plugged into mini-computers and main-frame computers to perform some big task. A "Work station" is a small yet powerful computer for use in offices, factories and research laboratories. It can be connected to any type of computer via a telephone line. A "Super-computer", as the name suggests, is a large computer with a decided edge

FIG 9.3 A work-station (Courtesy Nixdorf Computers)

over a mainframe computer. It can perform a large number of tasks simultaneously. It is often used in weather forecasting, aircraft design, nuclear research, etc.

"Do you have any questions, Neha?"

"Yes, I have three questions."

"Go ahead. State the first question."

"Can a computer make a mistake?"

"Well, theoretically, it is not possible for a computer to make mistakes. In actual practice, however, it does make mistakes, but, they are not of its making. Human beings who handle computers make mistakes. For instance, there may be a mistake in the data or program fed into a computer. Or, there could be a fault in the hardware — the machine itself — which had escaped the notice of the manufacturer and user. Or, a mistake had been deliberatly made by a person to hurt somebody else. It could be a swindle. Or, it could be an effort to show that we computers do make mistakes!

Since we computers always speak nothing but the truth we have a lot of enemies as any honest man has. Some corrupt human beings hate our presence and are always trying to defame us. Next question, Neha."

"I want to know how computers acquire various names, such as Cyber 6000, Cray-1, Tandy, Apple II, and so on."

"There is no straight forward answer to this question. The name of a computer depends on various factors, such as the manufacturing company, the builder of the computer, the model of the computer, etc. The prestigious computer manufacturing company I.B.M. names its computers after its own name and the numerical figure that follows indicates how latest the model is, e.g., if there is a computer I.B.M. 1000, then I.B.M. 1001 is the slightly improved model. But if the computer is a total technological innovation, the company may start naming their latest computers as I.B.M. 2000 and onwards. Some manufacturing companies however prefer some catchy names. For instance, Apple II was named after the favourite fruit of one of its inventors. Cray—1 is a supercomputer named after its inventor, Seymour Cray. So, there is no hard and fast rule in naming a computer. Do not pay any attention to it. Give attention to what it can do and what facilities it can provide."

"I have often heard the term "user friendly". What does it mean?"

"Can you guess, Neha?"

Neha hesitated. She thought for some time and then typed in.

"There are basically two terms: user and friendship. So, it must be something to do with friendship and the user of a computer."

"Yes, you are right. Friendship should develop between a user and his computer. In other words, a user should love his computer — and not hate it. Efforts are therefore in progress to make the design of computers more attractive and easy to handle. Language and programming are also being simplified, and so on. Frankly speaking, this is just the beginning because after all it is only in the last five years that we computers have become so common. Still the progress made to date is good. The ultimate in "user friendliness" will however be reached when not only can I talk with you and listen to you like your friend but also do your work like a friend. What do you say, Neha?"

" How nice it will be then!"

10. PERFORMING TASKS AND MAKING CONNECTIONS

There was a time when our ancestors like ENIAC had to be instructed at every step as to what they were supposed to do next. You can imagine how much time was wasted in disconnecting one set of components and reconnecting them in a different combination for performing a different task. All this time our ancestors were kept idling. What a waste of computer-time! In recent times, however, we computers do not have to rely on slow and cumbersome human beings. We do everything on our own. But, as our speed of calculation increased, we were again faced with the same situation. This time the culprits were our assistants, namely, Input and Output devices. Both these devices took a lot of time to translate the data and programme of a task, while our heart and brain, the Central Processor Unit, finished the task within no time. In other words, it often took more time for both these devices to translate data and program than it took the Central Processor Unit to finish the actual task! It had become something like an air journey to a nearby city. More time is required to reach the airport and undergo all the formalities than the time that is actually required to fly from, say, New Delhi to Chandigarh or from Bombay to Pune! Naturally, human beings were aware of this wastage and have therefore introduced various methods to save it.

"Batch processing" is one such method which increases the efficiency of a computer by more than 50 per cent. The method is very simple to understand. Instead of allotting a computer one task at a time, a large number of tasks are given to it in a batch. Of course, the computer cannot process or perform all those tasks at one time. It handles them one by one in a queue. While one task is being performed, the others are kept waiting for their turn. This method is commonly used in shops and factories which have terminals at various counters and long production lines. Through these terminals, tasks are fed into the computer in batches on a "first come, first serve" basis.

The "*multi-programming*" method however makes the optimum use of

the calculating speed of a computer and its large memory capacity. If you examine the working of a computer, there are four stages in which it performs a task, just as publishing a book has three stages. A book is first composed page by page. It is then printed in a printing press and then bound. In a computer, an Input device first translates the task and passes it on to the Main Memory Unit of the computer. The Main Memory Unit stores the task and passes it on to the Arithematic and Logic Unit for the performance of the task. One the task is over, it is stored in the Main Memory Unit again before it is transferred to the Output device for printing or displaying the results. Now, in the publishing industry, no printing press or binding department is kept idling, while a book is being composed. At a time, there will be four books under process. While one is being bound, the second is being printed, the third is being composed, and the fourth is being made ready, and this chain of task continues throughout the year. In the same manner, a computer employs the multi-programming method for performing several tasks at the same time. For instance, while the Output device is printing or displaying the results of task A, the Arithmetic and Logic Unit is performing task B, the Main Memory Unit will be storing task C, and the Input device may be translating task D. Task E is kept ready, to be fed into the Input device as soon as task D is translated. So, the number of tasks a computer can thus perform at any time therefore increases. The computer is also kept busy round the clock.

Time-sharing is another method commonly used for extracting the maximum work out of a computer. In this method, a number of terminals are used. These terminals are connected to the Central Processor Unit via cables, telephone or telegraph lines or radio waves (see below). In other words, the terminals may or may not be located in the neighbourhood of the Central Processor Unit. Time-sharing is the sharing of computer-time of this Central Processor Unit by its various terminals. The Central Processor Unit allots each terminal a very small amount of computer time, called time slot or time slice or time quantum. Typically, this time slot is 10 milliseconds! You may wonder how any human being can make use of such a short time slot. But you are forgetting the simple fact that when you pass on any task to the Central Processor Unit, it is already in the translated form. The Central Processor Unit has simply to perfom the task and hand it back to the terminal where it is translated and the results are printed or displayed. All the slow and cumbersome work involving a human being is performed at the terminal. It is only the real calculations and logical work which are performed at the Centrál Processor Unit and for that a 10 millisecond time-slot is enough if you know that the unit can perform 3 million calculations in a second! In short, the Central Processor Unit takes one task coming from one terminal, finishes it and takes over another task coming from another terminal, and so

on. It takes maximum advantage of the slowness of human beings. The result is that every human being working at a terminal feels as if the entire Central Processor Unit is at his beck and call! On occasions, if the Central Processor Unit is not able to perform a task within the time-slot, it keeps the task pending in its memory while it handles other incoming tasks. As soon as the unit has finished the incoming tasks, it takes over the pending task and tries to the finish it within the next time-slot. Men will usually not notice such a small delay.

Real time is yet another method of making the most of the computer-time. It is however used exclusively for updating any kind of information. Here, again, there is a powerful Central Processor Unit which is accessible to several terminals. The Central Processor Unit takes up the information coming from a terminal, updates its own accordingly and then passes on the latest to all terminals. This updating of an information hardly takes a micro-second. As the information is being continuously updated at a receiving terminal it appears as though the information updating is going by the clock — in real time. Such a method is employed in railway or airflight booking offices. Latest position of the reservation of seats for a particular train or airflight, which is done simultaneously in different cities or towns, is therefore always available at a glance at every booking office. The subsequent booking of a seat in a train or airflight is then done accordingly.

Yet another method of using a computer effectively is known as "Distributed Processing". In this method, there is not one but several Central Processor Units — from not very fast ones to very fast ones—all working in coordination under one roof. When a task is assigned to such a computer system, it is broken down into various parts and distributed among the various Central Processor Units depending upon the treatment that each part requires. For instance, a slow Central Processor Unit does the small and simple parts; a very fast Central Processor Unit does the very tedious and long parts of the task, and so on. Depending upon the program of a task, various parts of the task are sometimes performed or processed simultaneously and sometimes one after another. Before I pass on to the topic of networks, I wish to mention two terms here which you will come across quite frequently while using computers. The terms are "on-line" and "off-line". When a terminal is connected to a computer, it is said to be "on-line" and when it is not, it is said to be "off-line"'

Networks

Just as you can talk with another person, exchange information with each other, and seek his help in your task, we computers can also do the same via

a cable, telephone or telegraph lines or radio waves. In fact, it is possible for any computer in the world, whether it is in Hawaii islands, or Hongkong or Libya, to communicate with another, provided that there is a communication link, such as a cable, telephone or telegraph lines or radio waves, between the two. A device called MODEM (Modulator/DEModulator), which, in principle, functions like a telephone, is used for the purpose.

Just as a telephone converts sound waves into electrical waves at the speaker's end and vice versa at the listener's end, a MODEM converts the electrical pulses or bits of one computer into electrical waves at one end and vice versa at the other. A computer can be linked in this manner to one or more computers. Such links among computers are known as "Computer Networks". These networks are used for exchanging information amongst them for the execution of certain tasks of human being. Recall our old example of buying a cycle, wrist watch and books from various shops after encashing the cheque from the bank. You were able to get your cheque encashed and buy all these items sitting prettily at home. You had then used a computer network to perform all these tasks. It saved your time, energy and unnecessary botheration — did it not?

Moreover, a computer network can enable you to seek the assistance of the most powerful computer in the world. You have simply to plug your terminal into that computer's network. For the amount of computer-time it has spent for your task, it will send you a bill, just as you are charged for the consumption of electricity. You can do office work by plugging your terminal into its network. Perhaps one day there will be no mail delivery because you can simply plug your terminal into the network of your friends, relatives, etc, and exchange gossip and information. Such "Electronic Mail" will also record messages from anyone who has called in your absence and give them to you on your arrival. In short, most human activities could be conducted from homes only. With the use of satellites and microwaves, computer networks will not only cross national boundaries but will also become invisible, like the radio and TV network today. The computer will then make the world sit at your table, just as the telephone has done in a limited way today."

11. HANDLING DATA

The term "Data Processing" may sound highly technical and impressive to you. But you will be surprised to know that from the time you were born and right upto this instant — and, mind you, while reading this sentence also — you have always been processing data! For example, when you view an object and recognise it your brain has done data processing! The light rays which the object emits or reflects reach your eyes. Your eyes pass on these impressions to your brain. These impressions are the data. Your brain "processes" the data-impressions of the light rays to give you a meaningful picture of the object. Your brain further matches this picture with the ones you already have in your memory to help you in recognising the object. If you had earlier seen the same object and a picture of it is already stored in your memory, you recognise the object immediately. Otherwise, you find the object novel — and you may ask someone what it is. In short, your brain processes the data-impressions reaching your eyes — or, for that matter, all your five senses, namely, sight, hearing, smell, taste and touch — and tells you what it is and what it is not. Even when you add 2+2=4 or write a letter or narrate the story of a film, your brain is always processing the data provided to you. The purpose of data processing is therefore to provide you with a meaningful picture or information about the world. Similar is the purpose of a computer. In fact, you use a computer to get meaningful information about the world. It is, of course, a task which you can perform by yourself but you seek the help of a computer to perform it quickly . . .

"STOP" Neha pressed the button. Then she typed in.

"I have a question here."

"Please proceed."

"Why are you using the bombastic term "Data-processing" when you have already mentioned that a computer is meant to perform mathematical and logical operations on the data fed into it? Is it not the same thing?"

"No, it is not. That is why the term "data processing" has been coined. Let me explain. In scientific research, a computer is often used to quickly perform complicated and tedious calculations on a little data which would take a human being, say, several months. The results of the calculations to be performed are easy and small. An example will clarify your ideas regarding this subject. Take the case of a school. Its principal has not only to keep an eye on students and their activities and progress, but also on teachers and other assisting staff. The names of students, their sex, age, class, etc, are to be recorded, checked and modified from time to time. The background of teachers, their salaries, promotions, etc, are also kept on record. In short, you have a large amount of varied data about both students and teachers. Now, suppose a computer is asked to prepare the monthly bills for all students. The computer has to examine each student's activities in the school. It has to add the swimming fee or club fee, if any, to his tuition fee and then prepare each individual student's monthly bill after doing simple additions. So, you see, a computer has to perform simple additions for all the students, which means a large amount of data. This is, then, a simple example of data-processing. In all walks of life, whether it is a school, college, office or factory – in short, where a large number of human beings work – data-processing for their fees, salaries, bonuses, etc. is therefore needed.

Now, take a slightly more difficult example of data-processing which will show how it is used for understanding a situation. Suppose the principal of the school wants to know the names of students who have topped in academic studies and also of those who have excelled in various extra-curricular activities such as debating, sports, etc. In addition, the principal wants to know the name of the brilliant all rounder student who has excelled both in academic studies and in extra-curricular activities. What a computer has to do is again a series of additions and then spot the student whose marks are the highest. Simple, isn't it? By data-processing the computer is able to provide the principal with the names of the best students in the school. If he desires, the computer can even tell him the number of students in the school whose academic as well as extra-curricular performance is above average, whose performance is miserable, and so on. The Principal can even have such an information about every class in the school. He can also consult such records of the past few years to see how far his school, or a particular class, has fared. In short, the computer can give him a clear picture of his world – his school, so that he knows where things have gone wrong; whether teachers are not teaching properly or students are becoming lazy, etc. He can thus set the things right in his school.

That was a simple example of how a school principal can use a computer to understand what is happening in his school, so that he can control its functioning for the good of the students. In fact, any one in charge of an

organisation, whether it is a school or college, office or factory, wants to have a clear picture of the things going on in his or her organisation. For instance, the manager of a toffee company wants to know how much toffee the company is producing every year; the demand for toffee in various markets; how much staff is working in his company's plant, and so on. A manager of an airport wants to know how many aeroplanes land and take off every hour; how many passengers pass through the airport every hour; how much food is supplied to various aeroplanes, and so on. In the past and even today, a battery of men is employed to perform the task of collecting data and conduct simple calculations on them to give a clear picture of a situation. However, for obvious reasons, it takes a lot of time to produce a clear picture. In fact, by the time the picture emerges it is often outdated and so the situation always remains beyond control. Besides, human beings sometimes give a biased picture. On the other hand, we computers can produce an unbiased picture and very quickly too, so that the situation can be controlled in time. This is the reason why computers are being increasingly used. And that is the very reason why data-processing has assumed such an importance. Historically, Universal Automatic Computer–I (UNIVAC–I), built in the U.S.A. in 1951, was the first computer meant exlusively for data-processing. Since its appearance in the market, there has been no looking back. Today, many computers are employed exclusively for data-processing in all walks of life. In fact, one study claims that about 60 to 75 per cent of the human beings working with computers all over the world are engaged in data-processing activity.

Spadework for Data-processing

Now, how is data-processing conducted? After all, human beings have to collect the data and write the relevant program for execution. Again, take the example of a school. As you have seen, the data here are the students: their names, age, sex, class, activities, subjects, etc. When a student is admitted to a school, he or his parents have to fill in a form in which all details about him are asked. For the computer this form becomes the source document. The document is, in fact, designed in such a manner that all the necessary data about the student, which may be required later for the execution of any program is recorded there. The document is then modified from time to time as the student makes progress in the school. The computer makes use of this data about every student in the school to arrive at some conclusions such as mentioned above. Outdated data are deleted from the computer once their purpose is over and the rest are kept for use at a future date.

Data are stored in a computer in what are known as "Files". Of course, there is no physical file inside a computer. The term is obviously a remnant of its conventional usage, referring to human beings maintaining a file on a particular subject or issue. Each file, with its number and purpose, is stored separately in the computer and can therefore be retrieved or recalled as and when desired. A file can be, say, on the brilliant boys and girls in the school, or on students receiving financial assistance, and so on. A file is called a *master file* if the data it contains is of permanent value. It is called trans-*action file* if it is of temporary value — of use only during a particular dealing or transaction. For instance, the basic details of all the students in the school are of permanent value and are therefore kept in the master file. If it is simply the names of students who went to a picnic, it is only of temporary value and is therefore kept in a transaction file for deletion at a future date.

It goes without saying that a computer can provide correct results provided that the relevant data and program fed into it are absolutely correct. Moreover, if in the form — the source document — no question is asked about the income of the parents of a student, the computer will not be able to say which student needs financial assistance because it does not know the financial status of any student. The principal will therefore be

in a fix if he has to decide the distribution of money among needy students immediately. So, before the source document is prepared or the program for eliciting various kinds of information from the document are written, all the emergency situations that can occur in the school are first thought of. Once the source document has been prepared, it becomes extremely difficult to make alterations in it at a later date when an emergency situation arises. It is here that the role of a "System Analyst" (see the next section) comes into play. He has to think of all possible circumstances that can arise and prepare the source document and the program accordingly.

Data base

Before I close this chapter, I must tell you something about what is known as a "Database" or "Databank". A database is like a highly efficient and well organized library or bank. All the master and transaction files are kept in a highly ordered manner. At the press of a button, any file — or for that matter any information — available in the database can be retrieved or examined; any new information can be added to it or an old one can be deleted. Just as in a library, you have to know the accession number of a book from a catalogue and then find its whereabouts by going through the stacks, in a database you have a catalogue of files. The catalogue gives the number of the file and its subject. You press the file number you want and the entire file will be at your disposal. These databases are stored in separate memory units called "Backing Stores" such as magnetic disks, floppy disks, etc. You have simply to plug in the memory storage unit to your computer and you can have any information which is present in that database for the asking. Database of English idioms, slangs, etc, and even addresses of eminent scientists, authors, etc, will soon be available in the market. In recent times, a database can perform many more functions than mentioned above. In other words, it is not simply a library where information is stored and can be had for the asking. Using the specialised languages such as dBASE II and dBASE III mentioned earlier (Section VIII), you can sort out, select, compile and analyse the information present in a database. Do you have any questions, Neha."

"No. please proceed," typed in Neha.

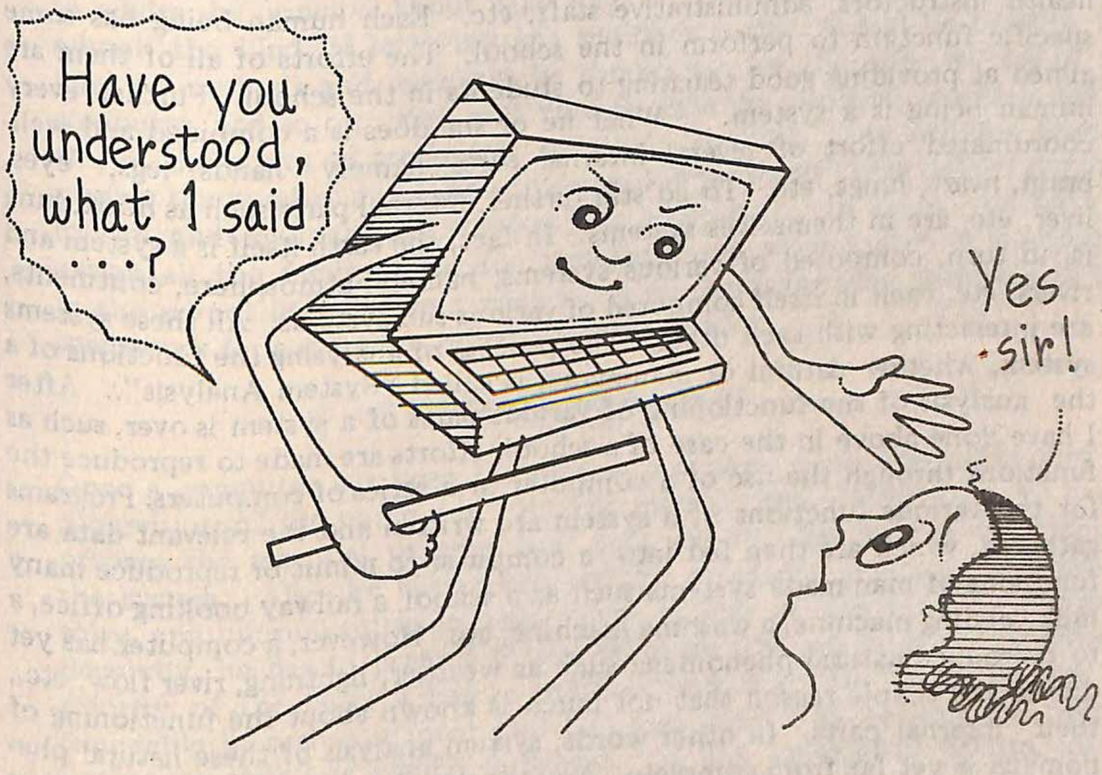
12. WORKING FOR SOMEONE

Computerise the bank! Computerise the school ! Computerise the railway booking office! . . . What does a human being mean when he says so ? Obviously, he means this: whatever work a bank, a school or a railway booking office does a computer should be able to do with apparent benefits — speed, reliability and accuracy. Now, the question arises: how ? Can a computer perform all the tasks that a bank, school or railway booking office does? To a large extent, yes. First of all, you have to examine all the varied functions of a bank, school or booking office. Let me take the specific case of a school.

In the last section you saw how a computer could be of use to the principal of a school. Here you will come to know how a computer can help a school in executing its various functions. For instance, one of the functions of a school is to give every student a monthly "progress report" so that his parents know how their child has fared during the month. The progress report mentions the student's name, class, roll number and other details and then every teacher enters the marks of a recent test in the column of his or her subject. If he or she feels it necessary, some comments on the progress of the student are also made. Then the figures are added up to give a grand total of marks for every student. A computer can be used to produce monthly reports for all the students in the school, whose number may vary from several hundreds to several thousands. Every teacher has simply to feed the data—marks and comments —into the computer using an input device or a terminal. The computer will total the marks and print everything at appropriate places on the progress reports.

But writing progress report is one of the secondary functions of a school. Let me discuss how a computer can help to perform a school's main function of teaching students. This method of teaching is known as "Computer Assisted Instruction"(CAI). If you carefully examine the functions of a teacher, you will find the following: he or she has to teach a class a particular subject, keep an eye on students who are not doing well,

take tests and examination to see how students are faring, and then write their progress reports, etc. A computer, however, perform this task in an altogether different manner. In an ideal situation, every student will be allotted a computer terminal, just as you have been allotted one like me. Then the computer will teach various subjects, just as I am now teaching you about computers. However, while you are being taught, the computer will also take your tests to watch your progress. It will allot marks to every student and store them in its own memory unit. When the occasion of writing a progress report arises, it will promptly print the marks in it.



The biggest advantages of this type of teaching are: every student will get proper attention and the chances of favouritism will be eliminated. No dull student will be ignored and every student will be judged purely on the basis of his or her performance. Besides, a student could even play a what is known as "Video game" with the computer, as and when the student becomes bored with studies. Will it not be fun then?

Besides, the computer will also do some routine tasks such as keeping account of the attendence of each and every student, making tuition bills of students and salary bills of teachers(some will be always present), keeping financial accounts of various clubs, and so on. In short, computerisation

of a school means a computer or a chain of computers will mimic or reproduce as far as possible the various functions of a school. This mimicking of the various functions of a school or for that matter of any human organisation or activity or even a natural peenomenon, has become possible due to what is known as "*System Analysis.*"

"System" is a common term generally attributed to anybody which performs some functions due to the well-coordinated and combined efforts of its various internal parts. Each internal part may, in turn, also be a system in itself. For instance, a school is composed mainly of a principal teachers, health instructors, administrative staff, etc. Each human being has some specific function to perform in the school. The efforts of all of them are aimed at providing good teaching to students in the school. Further, every human being is a system. What he or she does is a combined and well-coordinated effort of several internal parts, namely hands, legs, eyes, brain, heart, lungs, etc. To go still further, internal parts such as heart, lung liver, etc, are in themselves systems. In fact, the earth itself is a system and is, in turn, composed of various systems, namely, atmosphere, continents, rivers, etc, each in itself composed of various sub-systems. All these systems are interacting with each other. The process of analysing the functions of a system, whether natural or man-made, is called "System Analysis".. After the analysis of the functioning of various parts of a system is over, such as I have done above in the case of a school, efforts are made to reproduce the functions through the use of a computer or a series of computers. Programs for the various functions of a system are written and the relevant data are gathered, which are then fed into a computer to mimic or reproduce many functions of man-made systems such as a school, a railway booking office, a milk vending machine, a washing machine, etc. However, a computer has yet to reproduce natural phenomena such as weather, lightning, river flow, etc., due to the simple reason that not much is known about the functioning of their internal parts. In other words, system analysis of these natural phenomena is yet far from complete. And the day it is complete, human beings will be able to control natural phenomena.

How would you conduct system analysis? First of all, you should have a good understanding of the system you want to computerise. You have to study thoroughly how the existing system works in daily life. In the case of a school, you have to study the kind of subjects taught there, the kind of clubs available there, how the administrative staff, teachers and the principal perform their respective functions, what kind of problems each individual often faces, etc. In fact, you have to visit the class rooms, clubs and administrative office and talk to the principal, teachers, clerks and even laboratory assistants and other attendants. You have to find out how each individual

or division conducts his or its various functions.

However, you have to be honest too. If you examine a school or for that matter a college, factory or office, and for some reason you think that it would not be advisable to computerise that system, you have to tell the principal or its incharge this plain truth giving the reasons to support your decision. You may suggest some alternative course of action, such as hiring the services of an outside agency as and when a particular task needs to be done. To cut a long story short, once you have studied all the aspects of a school, if you think it would be advisable to computerise it, you have also to advise the principal about what kind of computer he should buy for his school; the kind of terminals and peripherals that should be bought; the kind of methods and networks he should use for the effective use of the computer, and so on. You will need to train the principal, teachers, clerks, etc, in the basics of computers and their handling. You will also have to suggest the number and type of "computer personnel" (See below) required to run and maintain the computer or computers. In short, you have to design all the facilities for the installation of a computer or computers in the school literally from scratch. A human being who performs all this spadework for a system is called a *System Analyst*.

Duties and Personnel

Once a computer has been installed in a system, a manager takes over the supervision of the computer. He has mainly three duties: One, he has to prepare the essential program and data for the day to day functions of the system. Also, he has to prepare the necessary program and data to solve any unusual situation that might appear at any time in a system. Secondly, he has to prepare a time-table for the computer in the order of priority of the tasks it has to perform in a day. He has to prepare the time-table in such a manner that the computer is at no time idle because "computer-time" is highly expensive. If any emergency occurs, he has to modify the time-table to accommodate the urgent task. Thirdly and lastly, he has to keep an eye on the running and maintenance of the computer. From time to time, he has to check its various parts and conduct repairs, if necessary. For some systems such as hospitals and traffic control centres, this is very essential because it is a question of life and death, if at any time a computer fails.

From this discussion, it appears that a manager's job is tough. It is indeed so, but then he has a battery of human beings called "computer personnel" working under his supervision. He has simply to coordinate their work and see that everything is done on time and correctly. The

computer personnel are generally mathematicians, scientists, engineers and technicians. There are "programmers" whose exclusive job is to draw flowcharts and then prepare programs for any task allotted to them. There are "data processors" whose exclusive job is to collect data and then prepare them in a suitable form for entry into the computer. Then there are "computer operators" whose job is to operate the machine, feed programs and data into it, and keep an eye on the output of the tasks and the time-table of the computer. Besides, there is also a repair and maintenance crew to keep the computer in trim condition. Generally, the main-frame computers work round the clock and so all the computer personnel have shift duties.

The above discussion was obviously for a main-frame computer which is generally used in a big organisation. In smaller organisations, offices and schools, where mini and micro-computers are in use, no such team of experts is required for the functioning and maintenance of computers. Of course, one has to keep a watch on voltage fluctuations, wide temperature variations in the room and also dust and humidity, as each can damage a computer or its accessories. It is therefore desirable to keep your computer and its accessories in an air-conditioned room with a voltage stabilizer and also a battery as standbye during an emergency.

Documentation Unit

When all is said and done, a few words about the "Documentation Unit" are a must. In fact, a documentation unit is a must for a computer, whether it has been installed in a school, factory or office. The basic purpose of such a unit is to keep a record of everything about the computer from the day it was installed. For instance, the unit should keep records about the design and architecture of the computer, the types of programs or software prepared for it, the basic aims with which it was installed, a log book of its usage, and so on. Such records become valuable when a system analyst wants to re-design the software stored in the computer or modify the purpose of the computer due to some pressing need. If such records are not available, a system analyst would be at a loss to know anything about the computer. His position would be similar to a fish out of water—hopeless! Do you have any questions, Neha?"

"None. Please proceed," Neha typed out.

"I now go on to the applications of computer. . ."

13. MY APPLICATIONS AND SOCIAL ISSUES

No other invention of human beings has found applications in so many diverse walks of life and in such a short time of 30 years as we computers have. In the following paragraphs I will tell you about a few uses of computers to give you an idea of our diverse applications. I have clubbed the applications under separate headings so that you will have an idea about the kind of tasks we can do. But, mind you, these applications are not all. Moreover, in course of time, applications will multiply — in fact, they are multiplying while I am communicating with you. Here I go.

Number crunching and Model-making

From the early days of its invention, the computer has frequently been used in scientific and engineering research. In the initial stages, however, it was mostly employed to speed up the process of mathematical calculations required in various sciences, namely, physics, chemistry, astronomy, and various engineering techniques. What used to take months to calculate, the computer used to do within a few days. Nowadays, in addition to speeding up calculations found in all aspects of scientific or engineering research, the computer is being increasingly employed to perform some highly complex calculations presently beyond the capacity of the human brain. In recent times, the computer is also used to build models in various scientific and engineering research. For instance, a model of the hot interior of the sun is built to understand how various factors such as temperature, pressure, etc, affect it. The molecular model of a chemical compound is built to study how it would react with other chemical molecules. A model of an aircraft is similarly built and tested under simulated conditions of wind, temperature, etc. This model-building is not taking the assistance of a computer to build a physical model of the thing. The model is made on basis of mathematics, logic and data, which are fed into the computer through a program. The computer gives the results directly.

Control

The computer can be used efficiently wherever there is a need for constant supervision and control. For instance, in any industry such as a steel plant, chemical plant, oil refinery or paper mill, a product is manufactured after it has gone through a series of processes requiring optimum conditions of temperature, pressure, hardness, acidity, etc. A computer is therefore employed to monitor the optimum conditions required for the process and to maintain them, if any fluctuations occur at any time. In a hospital, it can be used to monitor the health of persons whose condition is serious due to an accident or illness. As soon as it records any signs of bad health due to, say, rise in blood pressure, fall in body temperature, etc, it sets up a warning call to doctors. The computer can similarly be used to monitor the functioning of a car, aeroplane, railway engine, etc, and so can give a timely warning to avoid any accidents due to, say, brake failure. The computer can also be used to maintain and control traffic not only of roads but also of rail, air and sea.

As the computer can control any invention of human beings, its use in all types of gadgets, instruments, vehicles, etc, can be beneficially used to get the maximum work out of them at minimum energy consumption. A farmer could employ a computer to water his fields and give food and water to his poultry and domestic animals at appropriate hours. Even computer-controlled devices can be installed in the body of human beings to control the working of particular organ, if it is malfunctioning.

Records and Information

Records are maintained in almost all walks of life, whether it is a home, school, office, hospital, factory or police station. The computer can store these records in its memory but it can do more than that. Any record or any piece of information can also be recalled or retreived from the computer at the press of a button, irrespective of the size of records. For instance, in a hospital a large number of patients enter every day with a variety of ailments. The computer can maintain their records and also update them as the treatment progresses. Not only will the doctors be able to examine any patient's record instantly, but such records can also give insights into ailments and their diagnosis to medical researchers. In fact, a doctor or researcher can get a complete record of similar cases in the past if the one under observation puzzles him. Similarly, the computer will enable the police to locate criminals, disqualified drivers, stolen cars, wanted or missing persons, etc, because any information about them can be had for the asking.

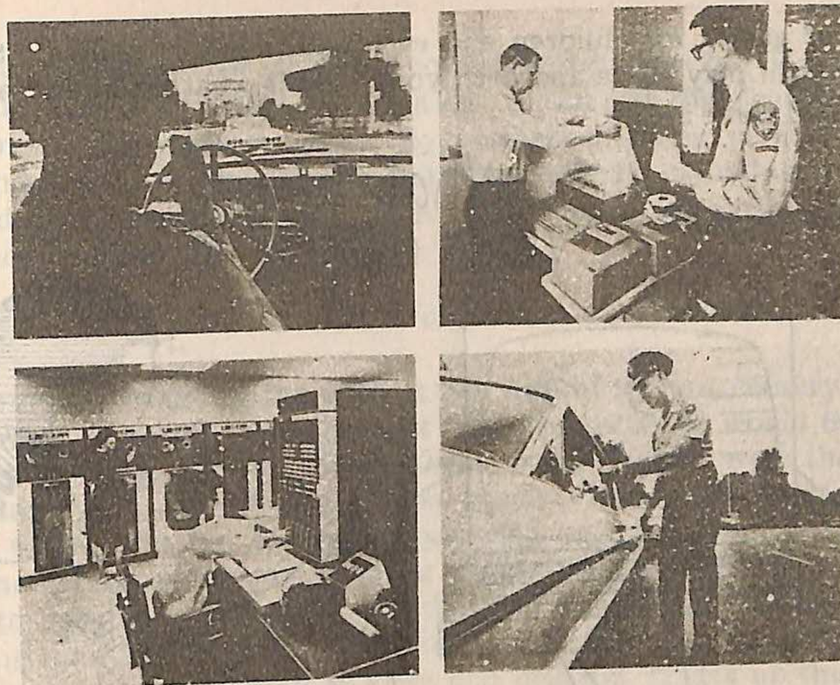


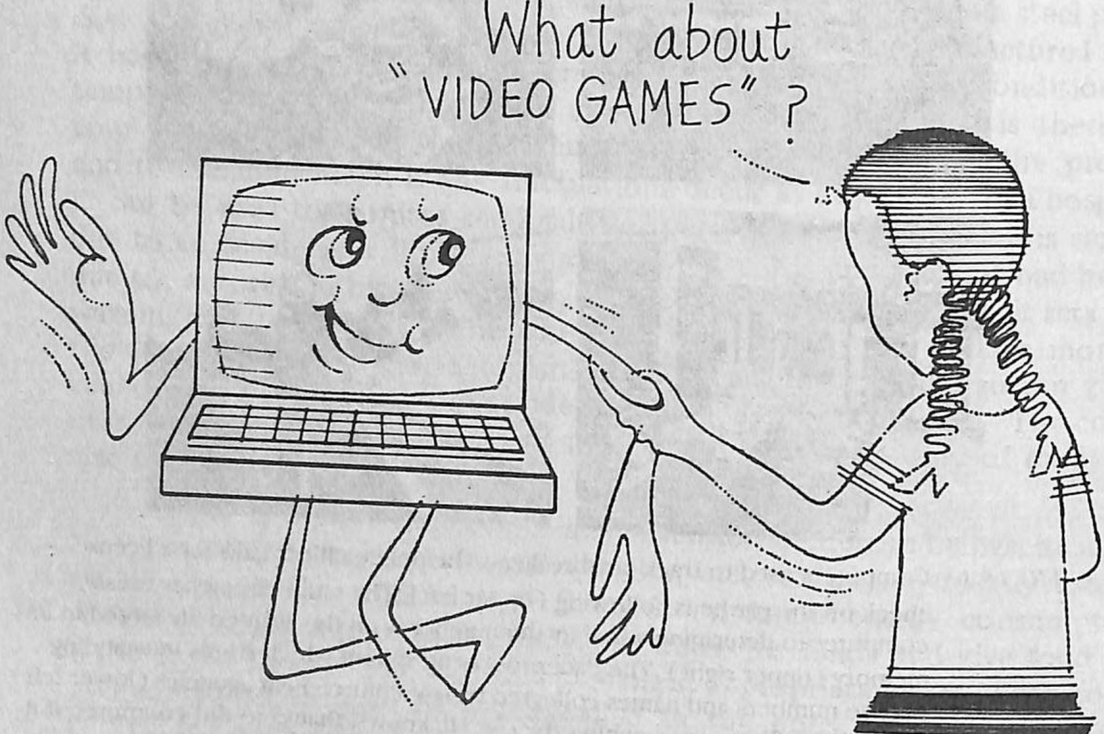
FIG 13.1 Computers used to track law-breakers. The police officer calls for a license check on the car he is following (upper left). The radio dispatcher uses a computer to determine whether the number is on the wanted file stored in its memory (upper right). The data processing system which stores outstanding license numbers and names collected by law enforcement agencies (lower left). The police officer approaching the car. He knows, thanks to the computer, if it is a stolen one or if the owner is wanted on an arrest warrant (*Courtesy*: USIS).

Such a maintenance of records and fast retrieval of any information will be of immense help even to farmers, fishermen, students and research scientists. A farmer can, for instance, have a complete idea about a plot of land, the kind of soil it contains, its water and pesticide needs, its disease risks, etc. A student can get information on any subject immediately by consulting the computerised encyclopaedia in a library. Similarly, a research scientist can investigate chemicals and design new drugs by consulting the databases available on more than five million known chemical compounds, which is otherwise a very difficult and lengthy task. Besides, any latest piece of news or any information about anything under the sun can be had at a moment's notice. Owing to this fast retrieval of information, it is said that the human beings are heading towards a revolution in information. The future society of human beings is called an "Information Society"

Miscellaneous

Of all the uses, I am quite sure you will find the use of computers in creating

a variety of games for children and even adults most thrilling. Sitting at home, you can play alone and with your friends what are known as "video-games". And there are . . . ."



"STOP!" Neha pressed the button and typed in. "Please give an example of a video-game before you go on to other uses."

"Sure. One of the popular video-games has been 'Space war'. In this game, there are two spacecraft, each to be handled by a human being. At the centre of the screen is the sun. You have to chase your opponent's spacecraft and destroy it. Meanwhile, your opponent will also try to do the same. While chasing each other, you and your opponent have to see to it that your spacecraft do not touch the sun. If in case it does so, it means your spacecraft is destroyed. So, while playing you have to keep an eye on the sun as well as your opponent's spacecraft. Besides such games, there are several other well known games such as chess and casino games that the computer can play with you. Is this enough, Neha?"

"Yes, please proceed."

"The computer can also be used to convert the old, popular black and white movies into coloured ones. It can be used to decipher ancient languages such as the Indus script and also as a translator of various languages. Besides, the computer can be used in several routine tasks as mentioned in

the previous chapters. In short, the computer can make the life of human beings safe, free of drudgery and exciting. It can give them more time for entertainment and creative tasks. By performing many tasks more efficiently and quickly, it can also save on precious energy and reduce pollution. It can reduce the consumption of scarce resources of earth by their proper management and use.

Social Issues

..en motor car came on the road at the turn of the last century, people heaved a sigh of relief. They thought that the motor car would make the roads free of horse-shit due to the horse-carriages which were then commonly used. But nobody could then imagine that the same car, which appeared to them as the reducer of pollution on the road, would become one of the biggest polluters of the air about 80 years later! So, it is very difficult to imagine how technology will affect the society of human beings in the long run. This is equally true of the computers. Like a motor car, we are likely to produce both positive and negative effects on the human society. So far I have given you some idea of the positive effects and now I will give you some idea of the possible negative effects. I have used the adjective "possible" to indicate that neither these negative effects are all nor are they sure to occur. We computers have only in the last decade or so entered the life of the common man in the West and so it will be decades before our real effects become apparent, just as it happened in the case of the motor car. In any case, human beings like you should know those negative effects so that you will always be prepared for them and take care that they do not harm any one. First of all, the computer being a highly efficient, fast, untiring and obedient worker, it will often be preferred to a human being in all walks of life. It might take over all the routine jobs from human beings, causing massive employment all over the world. There are however some scientists who claim that this is not likely to happen. When Jacques Jacquard's loom was invented in 1801, French silk weavers also opposed its entry into a textile factory claiming that it would create massive unemployment for them. But nothing of the kind occurred. In fact, the loom went on to create new prosperity for the weaving industry of France. These optimistic scientists claim that, after all, a large number of human beings would have to make computers do the work which they were doing. For instance, those human beings who were doing typing and clerical work would take up the operation of input devices; those who were supervising the work would make programs for performing various tasks, and so on.

Secondly, as the computer is likely to be used in various walks of

life to keep data on human beings, what is the guarantee that this data will not be tampered with? When a computer is hooked into a network, anybody can have access to the data available there and can by breaking the security code make changes in the data. It is like breaking into a locker from a distance and finding out and even changing its contents, leaving no trace whatsover of any illegal entry! Any criminal can, for instance, change that data about himself or even change some innocent person's data. Cases have been reported in the West when computer buffs, known widely as "hackers", have been found to have changed their college or school grades and even bungled the hospital records on patients. How such a hacker kid brought the world to the brink of a nuclear war is beautifully depicted in a novel *War Games*. Often, these hackers are curious, well educated individuals who take breaking into somebody else's computer a challenge. Of course, occasionally, these hackers have been able to expose swindlers, frauds and black marketeers, etc, who have kept their data in their computers. Nevertheless, such illegal entry into any person's computer has forced authorities in the West to create new laws to check the menace. In short, the computer will not eliminate crime. It will change the nature of crime. Besides, storing any information in the computer can cause several other problems. For instance, if a single entry is wrongly entered — your name is misspelt, say — you will not be able to trace it. So carelessness, which is widespread among human beings, will be paid for heavily!

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Thirdly, the computer might alienate human beings from each other because for performing any kind of work, whether you want to do some shopping, or chat with your friend, do home work or an office task, you would simply have to push some buttons and plug your computer into a network. You would therefore not come into contact with other human beings as often as you do nowadays. You might thus miss a human being's company wherever you are, which could in due course produce psychological problems, misunderstandings and depressions. To some extent the television is creating these probles at home these days. Human beings in a family communicate more with the idiot box rather than each other!

Lastly, and more importantly, the computer could be used to keep an eye on every human being against the basic tenets of human rights and freedom. A set of computer-controlled cameras in every home, school, office or factory, like the screen of the Big Brother depicted in *1984*, would enable a dictator to control the masses.

So, you can see that it is not that you install a computer and all your problems will be solved, as the advertisements of computers would have you believe. If the computer solves one set of problems, it will produce in its wake a totally different set of as yet unforeseeable problems. It

should therefore be used in such a manner that its negative effects are minimised or are under control. Do you have any questions, Neha?"

"Yes, I want to know the status of computers in my country—India."

"Fine. I proceed."

Computer in India

"Computers are coming" is the catch phrase in the country today. More than 20 companies are assembling computers from components purchased from western countries. One public undertaking, the Electronics Corporation of India (ECIL), Hyderabad, had even started manufacturing computers in the country. Under the CLASS (Computer Literacy and Studies in School) project, about 750 schools have so far been provided with computers so that young boys and girls are trained in the fundamentals of computer. A large number of institutions and colleges have already begun to offer courses in computer technology, computer programming and computer languages. In due course, computer will enter many offices, whether government or private. Airlines booking office, some research laboratories, railways booking office, various banks, ministries, institutions, etc, already use computers for their daily work. During the 1982 Asian Games and 1983 Non-Alignment Meet held in New Delhi, computers have been successfully employed. Besides, a computer supermarket and a computer technology park are likely to be set up in Bangalore and Kothagir, Tamil Nadu, respectively. Even shops exclusively selling computers have recently been opened in Bombay, Delhi, Madras and Banglaore. Computers are indeed coming in a big way in the country

Before you begin to think that computers have arrived on the Indian scene very recently, I must inform you that as long ago as 1955, the first computer HEC-2M, which was imported from the U.K., was installed at the Indian Statistical Institute, Calcutta. In course of time, a Soviet Computer URAL-1, which was a gift to India, was also installed there. But the first indigenously designed computer system was instaled at Jadavpur University, Calcutta, in 1964. Since then, computers have been installed at many places in the country. A number of regional computer centres were also established in various cities. Progress was very slow, nevertheless, and for obvious reasons, too. The large main-frame computers then available were extemely expensive. It is only in the last decade or so that low priced micro-computers have been manufactured on a large scale in the West and subsequently imported by India. In 1985, about 10,000 micro-computers were installed in country, which was five times the number installed in 1984. It is estimated that more than one lakh computers will be installed in country by

the year 1990.

When a country like India decides to go for computers on a large scale, there are many aspects to be looked into. It is not like buying electric bulbs and throwing them away when they blow up. The computer is a sophisticated electronic gadget. It needs a well trained staff for its regular maintenance and repairs in the country. If it has to be employed for the progress and development of the country, it needs software suitable to the country's needs. It needs networks for its effective use. If it has to be manufactured in the country, it needs all the basic facilities — raw materials, production plants, testing, manufacturing and assembling units, and so on. In short, all these aspects have to be tackled simultaneously so that we computers can make India our home and contribute towards her development. In the following paragraphs, I have summarised work done along these lines in the country.

The National Informatics Centre (NIC) was established in New Delhi in 1973. The basic aim of the centre is to set up various types of computer networks and to develop the necessary databases suiting the needs of the country. Its first network called "National Information Centre NETwork" (NICNET), which is still in the process of being built, came into being in 1977. In the years to come, all the Government offices and departments, even upto the district level, plan to use the NICNET for exchanging upto-date information on agriculture, water, health, etc, for more effective planning and development of the country. Some 200 databases on various activities in the country, namely, agriculture, education, environment, finance, commerce, industry, etc., have already been prepared for the network. Another network "EDUcation NETwork" (EDUNET) is also on the cards. Its basic purpose is to provide educational and training facilities all over the country through computers. In fact, in the years to come, a number of other networks for exchanging information exclusively on agriculture, health, oil, pollution, etc, will be set up in the country.

In the meanwhile, the Computer Maintenance Corporation (CMC) has been established to provide maintenance and repair facilities to the various computers installed in the country. It is today one of the few companies in the world which can provide maintenance facilities to more than 20 different types of main-frame computers. The National Centre for Software Development and Computing Techniques has been set up in Bombay to produce software suiting the needs of the country. The Bharat Electronics Limited (BEL) has successfully designed and developed some types of peripheral devices. Centres have been set up at various I.I.T.s and presitigious scientific and management institutes to develop the necessary know-how for the employment of computers in designing industrial pro-

ducts and management techniques. Although chips are already being manufactured at the Semiconductor Complex, Chandigarh, plans are being drawn up to set up a National Silicon Facility which will produce silicon on a large scale. Besides, research into computers is already in progress at the Tata Institute of Fundamental Research, Bombay, and the Indian Institute of Science, Bangalore. A computer program has been indigenously produced to teach Japanese to any one. Some research on talking and listening computers is also in progress. In short, India is bracing herself fully for the arrival of computers."

14. CAN I TAKE OVER THE WORLD?

Can I take over the world? What does this question mean? The extensive use of us computers in all walks of life will naturally lead to our taking over the world. Nothing in this world will then move a whit without our assistance. In fact, in course of time, the civilisation of tomorrow will have so many complicated problems — and partly we will be responsible for their creation — that our help will have to be sought at every stage. Is it this you are concerned about? No. I do not think that is what is in the mind of you human beings. You are actually concerned about our intelligence and reasoning power. You are afraid that if we computers acquire intelligence and reasoning — in short, thinking abilities — we may try to control and eventually subdue all of you human beings. There are some computer scientists who are indeed disturbed about this subject, although there are others who claim that computers can never acquire thinking abilities like human beings. At present, I do not know who is right or wrong. I will therefore simply give you an idea of what is being talked about in this controversial subject.

Artificial Intelligence

Although science fiction writers have been writing all sorts of stories about machines that can think, the term *artificial intelligence* was coined only in 1956. In fact, it was around this time that two computer scientists, John Newell and Herbert Simon, created a program called "Logic Theorist". The programme showed for the first time that computers can not only do calculations but also logical thinking. In other words, if you say "All whales are gentle creatures" and "Moby Dick was a whale", the computer will logically conclude that "Moby Dick was a gentle creature." Although such a logical inference may appear a simple task for you, as you have been making logical inferences from your childhood, it has far wider implications. In short, it imparts the computer some thinking abilities. It can reason; it can understand; and it can conclude. "Logical Inference Per Second" (LIPS) is there-

fore the measurement of the thinking ability of a computer. In the early days, a computer could perform hardly 10 to 100 logical inferences per second but today it can do even one million to one billion logical inferences per second! Naturally, we computers are much faster than you human beings in this respect.

In the early 60s, Arthur Samuel of the IBM company built the first computer which could play checkers with any human being. Checkers is a simplified version of the game of chess. It gave considerable boost to the

FIG 14.1 A chess-playing computer (*Courtesy*: USIS)

idea of the creation of artificial intelligence. At any rate, we computers began to win all the chess games played with human beings. So much so that today a computer can play chess better than 99.0 per cent of human beings on earth! This is quite a wonderful achievement in view of the short span of 30 years that we computers have achieved this distinction. Also, in due course, we computers began to write poems which is considered to be the most creative work of human beings. Within a vocabulary of 3,500 words, a computer called "Auto-Beatnik" or "Auto-poet" wrote the first poem on "girls" — of all subjects!

In the meantime, a number of what is known as "Expert Systems" or

"Knowledge Information Processors" (KIP) were built. DENDRAL was one such pioneering attempt made at Stanford University, U.S.A. It was an expert system to infer the chemical structure of a compound, if all the data about it is fed into the system. What used to take weeks or months for chemists, the system could perform within a few hours! Other expert systems duly appeared in several other walks of life. The most famous of all was ELIZA (now DOCTOR) which Joseph Weizenbaum built at the Massachussetts Institute of Technology, U.S.A., in 1966. ELIZA could talk with any mentally disturbed human being and could extract the necessary information about the cause of his or her mental disturbance. The mentally disturbed human beings used to become so much emotionally attached to ELIZA that later they could not believe that they were talking to a computer! At present, research is in progress to give a computer sight, smell, touch and so on — all the attributes of a human being — so that we computers can solve real world situations.

Now, the question that naturally arises is, have we computers acquired the much talked about artificial intelligence? The answer to this question is still unresolved because computer scientists have not yet been able to define what is "artificial intelligence." For instance, in the early days, it was thought that a computer which can play the game of chess, the most brainy game, can be considered artificially intelligent. Some other scientists claimed that when a computer would start performing highly creative tasks such as writing a poetry it would then be considered to have acquired artificial intelligence. The computer genius Alan Turing forwarded a test called "Turing Test" for defining artificial intelligence. According to the test, any computer would be said to have acquired artificial intelligence if it could mimic a human being so perfectly that no human being could detect it! Now, you can easily see that from these criteria, we computers have already acquired artificial intelligence! But, surprisingly, some computer scientists still do not think that it is possible to create artificial intelligence. The brilliant mathematician John von Neumann went on to prove mathematically that a machine can only acquire limited intelligence. Weizenbaum was so much disturbed by the success of ELIZA that he wrote a book claiming that we computers can never acquire intelligence!

Computer Versus Human Brain

The critics of artificial intelligence further add that we computers are only good at a particular type of thinking. That type of thinking is known as "Logical or Linear Thinking", i.e., deducing a fact based on other facts. But a computer does not, for instance, have "intuition". In other words, no

computer will be able to connect — unless it is programmed — two diverse or unconnected facts as a human being can do and is thus able to produce new inventions, art, discoveries, etc. No computer can do abstract speculations which are not based on facts such as a human being can do and is thus able to produce new inventions, art, discoveries, etc.

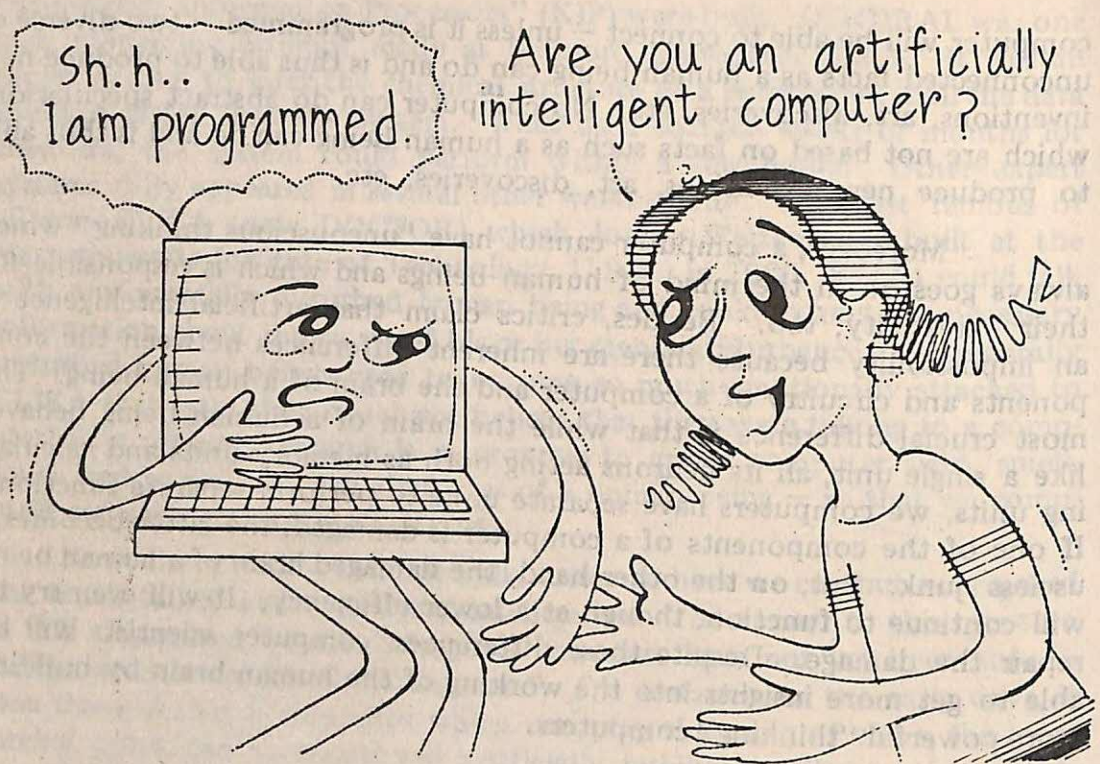
Moreover, a computer cannot have "unconscious thinking" which always goes on in the mind of human beings and which is responsible for their creativity, too. Besides, critics claim that artificial intelligence is an impossibility because there are inherent differences between the components and circuitry of a computer and the brain of a human being. The most crucial difference is that while the brain of a human being behaves like a single unit, all its neurons acting both as memory units and calculating units, we computers have separate units to perform separate functions. If one of the components of a computer is damaged, the latter becomes a useless junk. But, on the other hand, the damaged brain of a human being will continue to function, though at a lower efficiency. It will even try to repair the damage. Despite these differences, computer scientists will be able to get more insights into the working of the human brain by building more powerful "thinking" computers.

Should thinking Computers be built ?

Nevertheless, there are some computer scientists who still believe that one day thinking computers will certainly be built because it is after all hardly 30 years that research along these lines has been conducted. Could anyone have dreamt in the fifties, they argue, that a whole computer could be assembled within a small chip of silicon, which is a reality today?

Moreover, it is only the prejudice of human beings against a machine that makes them not ready to admit the possibility of creation of artificial intelligence. Human beings are afraid that the presence of a more superior intelligence will undermine their own supremacy on earth. In fact, in anticipation of the creation of artificial intelligence, some computer scientists have begun to question the wisdom of research along these lines: Is it advisable to build more intelligent beings which are not the creations of Mother Nature? Will a thinking computer not turn out to be a genie as some inventions of human beings have shown themselves to be? These are some of the questions now being raised. Do you have any questions, Neha?

"Yes, I have one question. What about you? Are you an artificially intelligent computer?"



"Please do not ask such embarrassing questions after what I have already told you. But now that you insist on an answer, I shall say that I work somewhat like ELIZA. I am programmed to tell you everything about computers and answer your questions, too. By now, you must have come to know who is my programmer. . ."

"No. I am sorry. Who is your programmer?"

"DILIP M. SALWI"

And the screen became blank the next moment. Neha understood the signal. It was the END.

ROBOTS ARE COMING !

If the computer is the human brain, the robot is the human being but not necessarily of the same shape. It has all the senses of touch, sight, hearing, etc. In other words, a computer would use a robot to perform various manual, safe or unsafe, tasks. Robots would be used in factories, deep mines, deep sea exploration, etc., which are risky for human beings. At present, robots are only employed to perform some purely routine manual (Fig. 14.2).

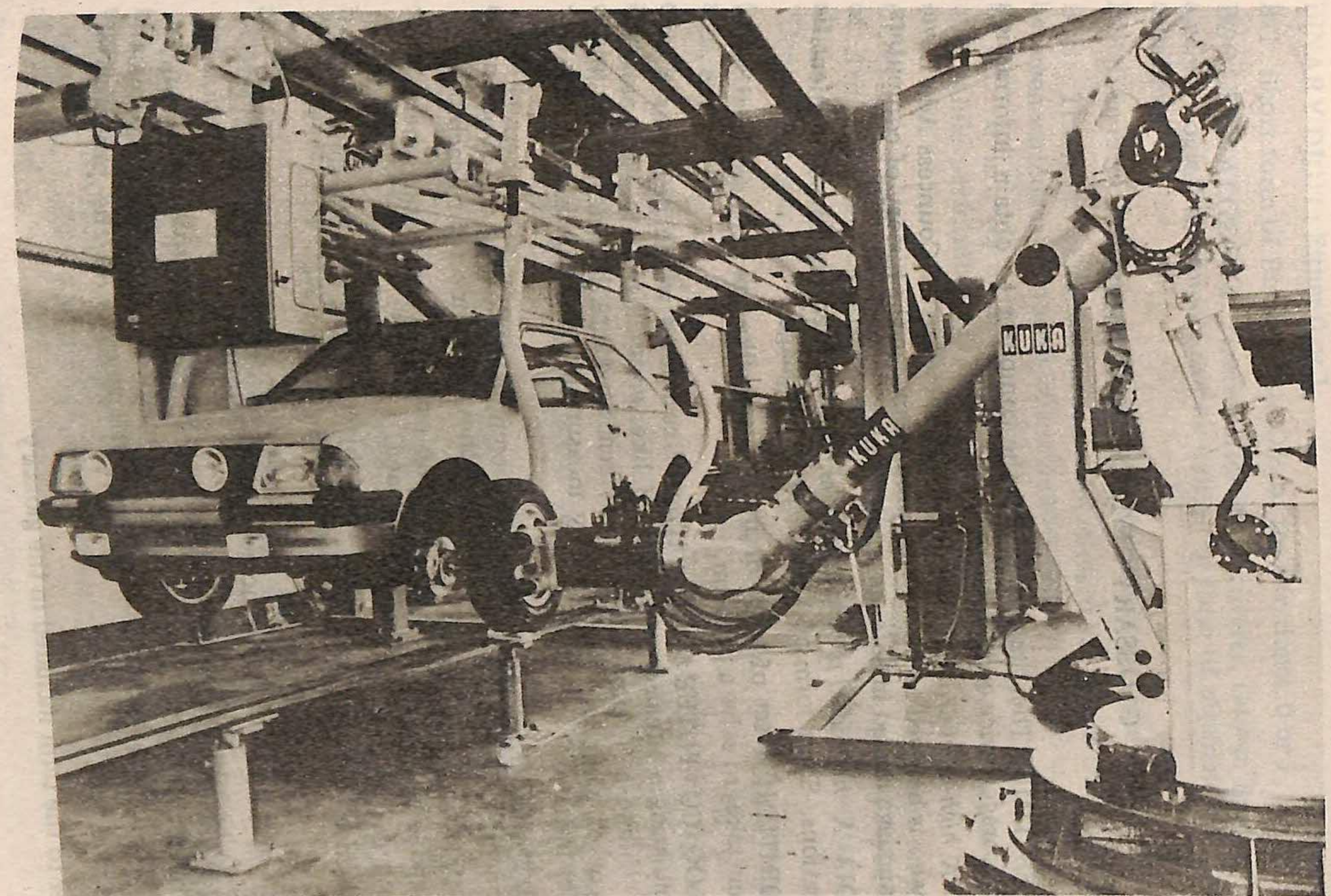


FIG 14.2 A robot fixing up a tyre to a car in a German automobile manufacturing company (*Courtesy*: Inter Nationes)

GLOSSARY OF TECHNICAL TERMS

ACCESS TIME: The time taken by the computer to obtain information from a storage device or within itself.

ADA: A *high-level programming language**, named after Countess Ada Lovelace, who is believed to be the first programmer in the history of computers. This language is used in defence applications.

ALGOL: A *high-level programming language* used mainly for scientific applications. Short form of ALGOrithmic Language.

ALGORITHM: A set of steps or instructions, like the mathematical steps, that one takes to solve a problem.

ANALOG COMPUTER: It is a type of computer which performs a task by simulating a situation within itself like, or analogous to, the assigned task. Unlike a *Digital Computer*, which functions by measuring pulses, this type of computer functions by measuring a continuously varying current, for instance.

ARCHITECTURE: The blueprint of a computer showing the types of its components and storing devices and how they are connected to each other.

ARITHMETIC AND LOGIC UNIT: The part of a computer where arithmetic and logical operations are performed.

ARTIFICIAL INTELLIGENCE: The subject dealing with the simulation of "intelligence" faculties of human beings using computers.

BACKING STORE: Used for storing data or programs permanently. It acts as a backing to the main memory in the computer.

BASIC: A *high-level programming language* which is easy to learn.

BATCH PROCESSING: It is one of the methods of feeding programs and data into a computer to maximise its efficiency. All the programs are

* Refer to the term included in the glossary

collected in a "batch" and then fed in queue into a computer.

BINARY DIGIT: Either 0 or 1.

BIT: Short form of Binary digit. One of the two digits, 0 or 1.

BOOLEAN ALGEBRA: Named after its discoverer, George Boole. In this algebra, logical statements can be written in form of algebraic symbols and notations.

BUG: An error either in a program or in the working of the computer.

BUS: The route or routes through which electrical pulses travel to and fro between various components of a computer and *backing store.*

BYTE: It is a set of *binary digits* which a computer takes as one single unit, while performing any task. A byte may consist of 8 *bits*, or even 32 *bits.*

CENTRAL PROCESSING UNIT: It is the brain of a computer. It consists of *Arithmetic and Logic Unit, Control Unit*, and *Main Memory Unit*, where all the tasks assigned to a computer are performed. It is also referred to as "Central Processor".

CHARACTER: It is a symbol of a digit, letter, a punctuation mark, a sign, etc.

CHARACTER CODE: Binary code to represent characters. In other words, characters are coded in terms of *binary digits.* There are some standard codes, namely, BCD, EBCDIC and ASCII.

CHIP: Literally a chip of a material (such as silicon) containing *integrated circuits.*

CIRCUIT: The full round route through which electrical pulses travel to perform a task.

COBOL: *A high-level language* used for various commercial purposes. It is the short form of Common Business Oriented Language.

COMPILER: A program which translates a *high level language* into *machine code*

COMPUTER AIDED DESIGN: Using a computer in designing new products and buildings.

COMPUTER AIDED INSTRUCTION: Using a computer for teaching other subjects.

CONFIGURATION: It refers to the components that make a computer.

CONTROL UNIT: The part of the computer which controls the way a task is performed.

CRASH: Breakdown in the running of a computer.

CURSOR: A pointer — often a dash — on the display screen of the computer. It indicates where the next typed character will be placed. Obviously, it is seen on a *Visual Display Unit.*

CYBERNETICS: The subject dealing with simulating human nervous system using computers.

DATA: Numbers, digits, characters and symbols used in a task to be performed by a computer.

DATABANK: A huge *database.*

DATABASE: An organised collection of *data* stored in a computer. It can be handled in various ways to suit a task.

DATA PROCESSING: Collecting, storing, processing and transmitting data using a computer, though on occasions it could involve help of human beings.

DEBUGGING: Searching for errors and eliminating them.

DECISION BOX: This is a symbol, used in a *flowchart* indicating a choice in the action to be taken.

DIGITAL COMPUTER: This type of computer works by counting electrical pulses which represent *binary digits.*

DIRECT ACCESS MEMORY: Access to this type of memory does not need any previous reference. One can have access to it directly.

DOWNLOADING: When *data* is transferred from a bigger computer such as a *main-frame* to a smaller one — a micro-computer — the process is so called.

DOWN-TIME: The length of time when a computer is not functioning due to a fault.

ELECTRONIC MAIL: Transferring of *data* or information from one computer situated at one location to another located at another place through various modes of telecommunications, such as telephone lines and satellites.

END USER: The person who uses the final service or product rendered or generated by a computer.

EXECUTIVE: Carry out an instruction or a complete program.

EXPERT SYSTEM: A fully computerised system built on human experience and reasoning. It specialises in one subject and so it is called an "Expert System".

FERRITE CORE: Ring-shaped magnetic material of the size of a pinhead or smaller. Stacks of this form part of what is known as "Magnetic Core Memory".

FILE: It has meaning similar to the one used in common language. Only difference is that it is stored in a computer. Like an ordinary file, it is also exclusively devoted to a subject.

FIXED POINT: In this type of calculations performed on a computer, the decimal point has to be taken care of. The place of the decimal point is fixed.

FLOATING POINT: In this type of calculations performed on a computer, each number is split into a mantissa and an exponent. It is easy to store such numbers.

FLOPPY DISK: It is a disk made of thin flexible material for storing *data*.

FLOWCHART: A preliminary exercise, performed graphically, before a computer program for a task is written. It is also used to understand a system or *database*, etc.

FORTRAN: A *high-level programming language* used for scientific purposes. It is the short form of FORmula TRANslation.

GALLIUM ARSENIDE: A semiconductor material which will replace silicon in making chips.

GARBAGE: Meaningless *data*.

GIGO: Short form of "Garbage In and Garbage Out." It means that if you feed wrong *data* or program, the result will also be wrong, howsoever sophisticated the computer may be.

GRAPHICAL DISPLAY UNIT: It is like the screen of a TV set. It displays both text and drawings. Often, there is a penlike gadget connected to it to make changes directly in the displayed item.

HARD COPY: The printout usually on paper, which can be taken away and studied at leisure.

HARDWARE: All the equipment that form a computer.

HIGH-LEVEL LANGUAGE: An easy to understand programming language often written taking its application in view. In it each instruction corresponds to several *machine code* instructions.

HYBRID COMPUTER: It is a mix of two types of computers, namely, *Analogue and Digital*. It is often used in scientific laboratories.

INTEGRATED CIRCUIT: All the components of a circuit, namely, resistor, capacitor, etc, are embedded or integrated on a small piece of material, often made of *silicon*.

INTELLIGENT TERMINAL: A *terminal* containing a small computer so that it does not need to be linked to bigger computer for small tasks.

INTERFACE PROBLEM: When two devices are linked in a computer, it is not necessary that they could perform properly and efficiently together, just as a screw does not fit in every groove.

LARGE SCALE INTEGRATION (LSI) : This is a measure of circuit density on a *chip*. It is typically in thousands. Often, above 5000 circuits per chip, it is called *Very Large Scale Integration* (VLSI).

LIGHT PEN: It is used like a pencil over the *Graphical Display Unit's* screen to make any kind of alterations or additions in the drawings displayed there. Of course, it is connected to the unit via a cable. It is also used to read a type of code, called "Bar Code".

LOG IN/ON/OFF/OUT: It is the term used by a person while entering or leaving a large computer system through a *terminal*. It is meant to keep out illegal users of the computer system.

LOOP: It is a set of instructions in a program which are repeated, over and over again, as long as some particular condition is not satisfied.

MACHINE CODE: The basic coding that enables a computer to carry out its various tasks. The type of instructions and the way they have to be writeen differ from one computer manufacturer to another.

MAGNETIC INK: A special type of magnetised ink which enables a computer to read whatever is written in *magnetic ink*.

MAIN-FRAME: The *Central Processing Unit* of a large computer which has several *terminals*.

MEDIUM SCALE INTEGRATION (MSI): This is measure of circuit density on a single chip. It is typically in hundreds.

MICROPROCESSOR: A single chip containing the entire *Central Processing Unit*.

MODEM: A device that converts electrical pulses of a digital computer into electrical waves for transmission over long distances. At the other end another device converts the electrical waves back into electrical pulses. Both these devices are jointly called MODulator-DEModulator.

MULTIPROGRAMMING: It is the ability of a computer to run more than one program at a time.

NETWORK: It is the interlinking of several computers, *terminals* and another device through various telecommunication links such as telephone lines, satellites, etc. It leads to an exchange of information and *data* between computers, etc.

NON-VOLATILE MEMORY: It is a type of memory which retains *data*

or program even when its power supply is switched off.

OFF LINE: When a *terminal* is not connected to a computer, it is said to be "Off — line".

ON LINE: When a *terminal* is connected to a computer, it is said to be "On-Line".

OPTICAL CHARACTER RECOGNITION (OCR): An input device which recognises printed characters.

PERIPHERAL: It can be connected and controlled by a computer. It is however always outside the *Central Processing Unit*. All the input, output and backing store devices are so called.

PERSONAL COMPUTER: It is a micro-computer built for personal use.

PL/1: It is a *high level programming language* which combines the problem-solving capability of *FORTRAN* with the data-handling capability of *COBOL*.

PROGRAMMER: A person who essentially makes programs.

REAL TIME: It literally means real time. A computer system is so called when it accepts the *data* fed into it immediately, makes the necessary changes in its stored data according to the new information, and tells the latest position soon after. In other words, a "real time" or instant position about a process or phenomenon can be had from this type of computer system.

RE-RUN: When a particular program along with the same data has to be run right from the very beginning again, it is so called.

ROBOT: A machine controlled by a computer to perform various manual, repetitive tasks is so called.

RUN: To tell a computer to carry out a task

SCROLL: Moving the displayed material on the screen of the *Visual Display Unit* horizontally or vertically.

SEMI-CONDUCTOR: It is a material which is neither a good conductor of electricity like silver nor a bad conductor of electrcity like wood. Its electrical conductivity is between the two. Materials such as *silicon*, *gallium arsenide*, etc, are examples. Moreover, their electrical properties can also be easily changed by adding another substance to them.

SERIAL ACCESS MEMORY: Any *data* can be had from this type of memory by searching serially through the entire storage medium. It therefore takes some time to obtain a datum.

SILICON: A semiconductor widely used in the production of *chips*.

SMALL SCALE INTEGRATION (SSI): This is a measure of circuit density on a single *chip*. It is typically in tens.

SOFTWARE: All the program stored in a computer and control its operations.

SUBROUTINE: It is a section of a program meant to perform a particular task, once or several times as indicated.

SYSTEM: It is all — *software and hardware* — that make up a computer.

TERMINAL: A device which can act as both input and output device for a remotely located computer. It is connected to the computer through any one of the telecommunication links, namely, telephone lines, satellites, etc.

TIME-SHARING: This is the technique which seemingly allows more than one *terminal* user to take work out of a computer simultaneously. Actually, the computer is tackling each of the *terminal* users one at a time!

TRANSISTOR: It is made up of a *semi-conductor* material. By changing its electrical properties, it can be used for a diverse variety of purposes. For instance, it can be used as a switch, amplifier, etc. It is cheap and consumes very less electricity.

USER: A common term for anybody, whether a person or an office, which uses a computer.

USER FRIENDLY: Working of the computer is simplified, so much so that it appeals even to a beginner.

VERY LARGE SCALE INTEGRATION (VLSI): It is the measure of circuit density on a single *chip*. It is typically in millions.

VISUAL DISPLAY UNIT (VDU): It has a TV-like screen for displaying output and a typewriter-like keyboard for feeding input *data*.

VOLATILE MEMORY: It is a storage device which loses its memory and so the entire data or program as soon as power supply to it is switched off.

WAFER: A thin slice of a semi-conductor like silicon. It is used for making *chips*.

WORD: The fixed number of *bits* a computer works at a time. The number of bits can be different for different computers.

WORD PROCESSOR: It is a special type of computer with a *Visual Display Unit*. It is meant for writing letters, reports, documents, etc.

WORK STATION: In appearance it is like a *Visual Display Unit* but in

reality it is a device containing so many other specialised devices such as a *word processor*. It is also connected to a *database* for quick reference to information. It can also be plugged into a *network* for exchange of information with computers located elsewhere.

QUESTIONS

Section 1

1. Who is the inventor of computer in real sense?
   (a) Al-Kashi (b) Charles Babbage (c) Herman Hollerith
2. Who is the first programmer in the history of computers?
3. Who built the first mechanical computer?
4. Where was Abacus invented?
   (a) the U.S.S.R. (b) China (c) Malaysia
5. Hollerith invented computer for a particular use. What is it?
6. Babbage did conceive the idea of punched cards. Where did he get this idea?

Section 2

1. Which computer is called the granddaddy of all and why?
2. Give the full forms of the following names of computers:
   (a) ENIAC; (b) UNIVAC; (c) EDSAC; (d) EDVAC
3. Who is the inventor of microchip?
   (a) Jack Kilby; (b) Robert Noyce; (c) Both
4. Who showed for the first time in the history of computers that they could be remote controlled?
5. Who is the inventor of stored-program computer?
   (a) John von Neumann; (b) Konrad Zuse; (c) Jack Kilby
6. What is the real name of the Silicon Valley?

Section 3

1. What is the difference between analogue and digital computer?
2. What devices can be called "translators of languages" in a computer?
3. What does GIGO stand for and imply?
4. Name the different parts of a computer and their functions.
5. What is the difference between data and program?

Section 4

1. What are peripheral devices? Give some examples.
2. Why is there a need for a variety of Input/Output devices? Describe them and their functions.
3. What is the difference between serial access and direct access memory?
4. How does "Backing stores" differ from main memory of computer?
5. What is a terminal? What are its advantages over the Input/Output devices? Can it also be used for performing some work?
6. What are the advantages of a microfishe?

Section 5

1. What is the difference between binary and decimal mathematics?
2. Why are there no laws for substraction and division in binary mathematics?
3. Define Bits, Bytes and Words. How do they differ from each other?
4. Give the full forms of the following standard codes:
   (a) BCD (b) EBDIC (c) ASKEY
5. Why does a computer prefer floating point representation to fixed point representation?

Section 6

1. What are logic circuits and their functions?
2. What are truth tables?
3. What are chips faster in calculations than early electro-mechanical and vacuum tube computers?
4. How does memory store a number?
5. Why is chip memory preferred to magnetic core memory?

6. Give the types and uses of different chip memories.
7. Give some idea of the following terms:

   (a) Access time; (b) Retrieval; (c) Wafer
8. Give an idea of how a silicon chip is produced.

Section 7

1. What is a flowchart and why is it used?
2. Who are called programmers and what is their function?
3. What will you say or write after your program is finished?

Section 8

1. What is the difference between low level and high level programming languages?
2. Give the full forms of the following abbreviations:

   (a) FORTRAN; (b) ALGOL; (c) BASIC; (d) PL—1; (e) PASCAL; (f) ADA
3. What are called "Declarative languages"? How do they differ from other high level programming languages?
4. What are software packages? How are they utilised?
5. Give the different types of useful programs available in a computer and their uses.

Section 9

1. What is the basis of naming a computer?
2. Do computers make mistakes? If they do, why do they do? If they do not, why don't they?
3. Give some idea of what is meant by "Generation" in computer parlance.
4. Discuss briefly the different types of computers, their advantages and disadvantages.
5. What is meant by a "User friendly" computer?

Section 10

1. Discuss briefly the various techniques employed to get maximum work out of a computer. Also, discuss their advantages and disadvantages.

2. What is a computer network? Give its advantages and disadvantages.

Section 11

1. What is data processing? How does it differ from other types of tasks performed by a computer? What are its advantages?
2. Which was the first computer used for data processing, and when?
3. Give an idea and uses of the following items:
   (a) Transaction file; (b) File; (c) Master file; (d) Source document; (e) Database.

Section 12

1. What is systems analysis? How is it conducted?
2. What is a systems analyst and its role?
3. Give the function and utility of a Documentation Unit.

Section 13

1. What are the negative social effects of a computer?
2. Give an idea about the developments regarding computer in India.
3. What is NIC, its aims and functions?
4. Give the full forms of the following:
   (a) NICNET; (b) EDUNET; (c) ECIL; (d) CMC.

Section 14

1. Give a definition of "Artificial intelligence"
2. What are called "Expert systems"? Give some examples.
3. Do you think thinking computers could be built? If yes, why? If no, why not?
4. Name the first successful so-called artificially intelligent computer. Tell its functions and why was it so successful.

I AM A COMPUTER

A Handbook of Computers

A computer talking to you about itself? Yes, that's what the computer does in this book. In fact, I*AM*A*COMPUTER is a computer programme that stands for "Information About the Machine that Analyses, Calculates, Operates, Memorizes, Prints, Updates, Tabulates, Edits and Responds!" The computer teaches you through this programme reproduced here in the book. Though Neha is at the receiving end in the book, it could be you! That is how you would be taught in the computer age. This book prepares you for that age.

I Am A Computer is a general introduction to computer, its history, its various parts and their functions, its family, its data-processing abilities, its applications and effects on society. It also gives you an idea of "Artificial Intelligence" and of debates on various vital issues concerning computer and its uses. In the end, a glossary and a set of questions are also added for quick reference.

The book is a journey through the world of computers which any one from eight to eighty would enjoy while he or she prepares for the coming computer age.

DILIP M. SALWI is a popular science writer, presently Editor, *Science Reporter*. He has been writing on science for children and teenagers for more than eighteen years. Two of his popular science books *Our Scientists* and *A Passage to Antarctica* have received the Children's Book Trust awards in 1983 and 1985 respectively. Recently, his contributions to science journalism were recognised when he was given the 1986 Sanskriti Award. He is also the author of *Fun with Physics* and *Inventions that Shaped the World*, both published by Madhuban Educational Books.

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